CENTRAL UNIVERSITY OF KARNATAKA

KALABURAGI

(Established by an Act of the Parliament in 2009)

B.Tech. in Mathematics and Computing

SCHEME OF INSTRUCTION AND SYLLABI

(Effective from 2023-24)

DEPARTMENT OF MATHEMATICS

SCHOOL OF PHYSICAL SCIENCES

Vision and Mission of the Department of Mathematics

VISION

To be among the best Mathematics Departments in the country and to establish an international reputation as a centre for research and teaching in Mathematics.

MISSION

- To attract motivated and talented students to the undergraduate, master's and doctoral programmes of the Department.
- To provide a stimulating teaching and research environment for the undergraduate, post graduate students and research scholars of the Department.
- To provide the best possible facilities for our students, particularly in the areas of computer facilities, library facilities and administrative support.

About the Dept. of Mathematics, CUK:

The Department of Mathematics was established in 2012 as a constituent of the School of Physical Sciences. Mathematics is important for all the departments of CUK. The Department of Mathematics shares the vision of our University in striving for excellence in teaching and research. Currently the Department not only teaches various topics in Mathematics to undergraduate and postgraduate students of different engineering and science departments, but also runs its own UG, PG & PhD courses in Mathematics. The curriculum of UG and PG courses are designed in a unique way to nurture future industry professionals and scientists. The frontier areas of research of the department include Fluid Mechanics, Number Theory, Computational Fluid Dynamics, Numerical Analysis, Theory of Hydrodynamic Stability and Mathematical Theory of Control. The laboratories in the Department and the computer centre are equipped with modern facilities to provide a good work environment. The students are trained in several computer programming languages like C, C++, and FORTRAN. They also gain exposure in handling problems through mathematical software's like MATLAB, Mathematica, Python, Scilab, Maple, R etc.

The academic programmes of the Department are designed to attract motivated and talented students to the master's and doctoral programmes of the Department. The faculty strives to

provide a stimulating learning environment for the undergraduate, post graduate and doctoral students of the Department. To meet these objectives, the Department is setting up excellent computer facilities, library facilities and also provides good administrative support.

Programmes Offered:

Programme	Duration
B.Tech. in Mathematics and Computing	8 semesters
M.Sc. Mathematics	4 semesters
PhD. Mathematics	Minimum 3 years (6 Semesters)

About the Programmes:

B.Tech. in Mathematics and Computing

The B.Tech. Mathematics and Computing undergraduate program will start in the forthcoming academic year 2023-24. This programme covers the basic courses in sciences and engineering along with programming, multidisciplinary courses, skill enhancement and value added courses, core foundational courses from pure mathematics, applied mathematics, statistics, and computing laboratory courses on machine learning, artificial intelligence, data analytics using computational software. It also covers advanced mathematics and computational mathematics electives along with minor and major research projects. After successful completion of this Mathematics and computing program, students will be able to pursue their dream of being industry professionals and also provide an opportunity for higher education in mathematics, computer science, artificial intelligence, etc. in most of the premier institutions/universities across the globe.

M.Sc. Mathematics

The Department of Mathematics offers a 4 semester (2 year) Master's degree programme to prepare students for a career in teaching and research. The entire curriculum is designed to prepare a student to enter a research career in multi-disciplinary areas of science and technology in Research Organizations and Industry. The students could also take up a teaching career especially after acquiring a PhD. degree. Further, this program helps the students to orient themselves towards a career in the industry. The main objective of the M.Sc. Mathematics program is to provide students with a strong theoretical background in mathematics for pursuing research in both pure and applied mathematics.

Thrust Areas of Research:

Finite Difference Methods; Computational Fluid Dynamics; Semi-analytical Techniques; Fluid Dynamics; Convective heat transfer in Nano and Hybrid Nanofluids (Theoretical and Experimental Studies); Bio Mechanics; Numerical Analysis; Number Theory; Theory of Partitions; q-series; special functions; Graph Theory; Mathematical Theory of Control; Fractional Differential Equations and Partial Differential Equations.

Learning Outcomes-Based Curriculum Framework (LOCF)

Name of the School: School of Physical Sciences

Department: Mathematics

Program: B. Tech in Mathematics and Computing

MISSION STATEMENTS:

MS-1. To attract motivated and talented students by providing a stimulative teaching and research environment where they can learn and develop the mathematical and computational skills needed to formulate and solve real-world problems.

MS-2. To inculcate innovative skills and ethical practices among students to meet societal expectations.

MS-3. To provide the best possible facilities and produce professionally competent, socially committed students through quality education and research.

MS-4. To build skilled IT professionals where computing is required for solving real-world problems.

MS-5. To groom the students to become technically competent and skilled intellectual professionals to address the challenges in the current computing areas.

Qualification Descriptors (QDs)

QD-1: Ability to understand the use of various mathematical concepts with computational techniques for problem solving & interpretation, and also the program core to address the challenges faced in mathematics and other related interdisciplinary fields.

QD-2: Facilitate as a deep learner and progressive careers in teaching, academia, research organizations, national/international laboratories and industry.

QD-3: Building professional competence in terms of applying mathematics and computer science knowledge in interdisciplinary projects and research.

QD-4: Communicate effectively with team members, engage in applying technologies and lead teams in the industry.

QD-5: Ability to adopt critical thinking, right moral and ethical values that compassionately foster the scientific temper with a sense of social responsibility.

QD-6: An ability to design, implement and evaluate a computer-based system, process, component, or programme to meet stakeholder needs. Also, assess the computing systems from the viewpoint of quality, security, privacy, cost, utility, etiquette and ethics.

Mapping Qualification Descriptors (QDs) with Mission Statements (MS)

	MS-1	MS-2	MS-3	MS-4	MS-5
QD-1	3	2	1	1	1
QD-2	1	2	3	3	2
QD-3	1	1	2	3	3
QD-4		2	2		2

QD-5		3	2	1	2
QD-6		2	1	3	3

Write '3' in the box for 'High-level' mapping, 2 for 'Medium-level' mapping, 1 for 'Low-level' mapping.

Program Learning Outcomes (PLOs)

PLO-1: Ability to develop logical and critical thinking, formulate, analyze, and solve real-world engineering problems through mathematical & computational techniques and perform the computations.

PLO-2: Gain and apply the knowledge of basic scientific and mathematical fundamentals to understand nature and apply it to develop new theories and models. Also, the use of research-based knowledge and research methods including designing of physical/computational experiments and evolving appropriate procedures to a given problem.

PLO-3: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling to complex computer science and engineering activities with an understanding of the limitations.

PLO-4: Design solutions for complex computer science and engineering problems and design system components or processes that meet the specified needs with appropriate consideration for public health and safety, and cultural, societal, and environmental considerations.

PLO-5: Analyze large data samples and discover knowledge to provide solutions to engineering problems. Also, communicate effectively on complex engineering activities with the engineering community and with society at large, such as comprehending and writing effective reports and design documentation, making effective presentations, and giving and receiving clear instructions.

PLO-6: To develop computing and technological advances for the appropriate societal problems. Also, understanding the impact of professional engineering solutions in societal and environmental contexts, and demonstrating the knowledge of, and need for sustainable development.

PLO-7: To analyze, create and develop algorithms and computing systems by applying mathematical and statistical approaches in interdisciplinary applications.

PLO-8: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's work as a member and leader in a team, to manage projects and in multidisciplinary environments.

PLO-9: The ability to function effectively in teams to accomplish a common goal. Also, apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PLO-10: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Mapping of Program Learning Outcomes (PLOs) with Qualification Descriptors (QDs)

	QD-1	QD-2	QD-3	QD-4	QD-5	QD-6
PLO-1	3	2	3	1	1	2
PLO-2	1	1	3	1	3	3
PLO-3	2	1	2	1	2	3
PLO-4		2	2		2	3
PLO-5	1	2	2	2	3	3
PLO-6	1	1	1	1	3	3
PLO-7	3	1	3	1	2	2
PLO-8	2	1	2	2	2	2
PLO-9			1	3	3	1
PLO-10	1	1			2	3

Write '3' in the box for 'High-level' mapping, 2 for 'Medium-level' mapping, 1 for 'Low-level' mapping.

CENTRAL UNIVERSITY OF KARNATAKA, KALABURAGI

PROPOSED MODEL CURRICULUM COMPONENTS

Comparison of suggested breakup of AICTE and CUK Curriculum

Credit Distribution for B. Tech. Mathematics and Computing Program (2023-2024 batch and onwards)

Category of Courses	Proposed Credits by CUK	AICTE Suggested Credits	Comparison
Basic Science Courses (BSC)	22	25	-3
Engineering Science Courses (ESC)	24	24	0
Humanities and Social Sciences including Management courses (HSC)	12	12	0
Program Core Courses (PCC)	48	48	0
Departmental Elective Courses (DEC)	21	18	3
Open Elective Courses including Mandatory Courses (OPC)	13	18	-5
Program Major Research Core Project (PRC)/Skill Development (SD)/Summer Internship(SI)	24	15	9
Total	164	160	4

	B. Tech (Mathematics and Computing) Credits in Each Semester								
	I	II	III	IV	V	VI	VII	VIII	TOT
BSC	4	9	0	4	4	1	0	0	22
ESC	6	0	2	8	5	0	3	0	24
HSC	2	2	0	4	0	4	0	0	12
PCC	6	3	13	6	4	9	7	0	48
DEC	0	0	0	0	6	6	6	3	21
OPC	3	5	5	0	0	0	0	0	13
PRC/SD	0	2	0	0	3	1	4	12	22
Internship	0	0	-	-	-	-	2	0	2
	21	21	20	22	22	21	22	15	164

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B. Tech in Mathematics and Computing Course Structure for the academic year 2023-2024.

Semester-I							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	UMATC10100	Calculus	5	1	0	**06**	**PCC**
2	UMATC10101	Engineering Physics	3	0	0	**03**	**BSC**
3	UMATC10102	Introduction to Electrical Engineering	3	0	0	**03**	**ESC**
4	UMACC10100	Introduction to Computing	2	0	2	**03**	**ESC**
5	-	Multidisciplinary Course	3	0	0	**03**	**OPC**
6	UMATA10100	A course on English Language	2	0	0	**02**	**HSC**
7	UMAPC10100	Computer Aided Engineering Graphics	0	0	2	**01**	**BSC**
		TOTAL	**18**	**1**	**4**	**21**	

Semester-II							
S. No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	UMATC20103	Ordinary Differential Equations	3	1	0	**04**	**BSC**
2	UMATC20104	A course on Chemistry/Biology/Mechatronics /Electronics	3	0	0	**03**	**BSC**
3	UMATC20105	Enumerative Combinatorics (Mathematical Foundations for Computer Science)	3	0	0	**03**	**PCC**
4	-	Multidisciplinary Course	3	0	0	**03**	**OPC**
5	UMATA20101	A course on English Language	2	0	0	**02**	**HSC**
6	-	A course on Environmental Sciences (Mandatory Course)	2	0	0	**02**	**OPC**
7	UMACC20101	Matrix Computations	1	0	2	**02**	**BSC**
8	UMACS20100	Introduction to Python Programming	1	0	2	**02**	**SD**
		TOTAL	**18**	**1**	**4**	**21**	

Summer Internship – I[#]

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Semester-III							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	UMATC30200	Linear Algebra	3	1	0	**04**	**PCC**
2	UMATC30201	Introduction to Number Theory	3	1	0	**04**	**PCC**
3	UMATC30202	Computational Algebra	3	1	0	**04**	**PCC**
4	-	Multidisciplinary Course	3	0	0	**03**	**OPC**
5	-	A course on Indian Constitution/Essence of Indian Knowledge Tradition (Mandatory Course)	2	0	0	**02**	**OPC**
6	UMAPC30200	Computing Lab for Linear Algebra & Number Theory	0	0	2	**01**	**PCC**
7	UMACC30200	Programming in C++ with OOPs	1	0	2	**02**	**ESC**
		TOTAL	**15**	**3**	**4**	**20**	

Semester-IV							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	UMATC40203	Mathematical Methods	3	1	0	**04**	**ESC**
2	UMATC40204	Introduction to Artificial Intelligence and Machine Learning	3	0	0	**03**	**PCC**
3	UMATC40205	Real Analysis	3	1	0	**04**	**BSC**
4	UMATC40206	Computational Statistics	3	1	0	**04**	**HSC**
5	UMATC40207	Partial Differential Equations	3	1	0	**04**	**ESC**
6	UMAWC40200	Programming Workshop (Data Analytics using R Programming and GPU computing)	1	0	2	**02**	**PCC**
7	UMAPC40201	Lab on Artificial Intelligence and Machine Learning	0	0	2	**01**	**PCC**
		TOTAL	**16**	**4**	**4**	**22**	

Summer Internship – II[#]

Semester-V							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	UMATC50300	Scientific Computing for Engineers	3	1	0	**04**	**ESC**
2	UMATC50301	Fluid Mechanics	3	1	0	**04**	**BSC**
3	UMATC50302	Database Management Systems (DBMS)	3	0	0	**03**	**PCC**
4	UMATLXXXXX	Departmental Elective I (Mathematics)	3	0	0	**03**	**DEC**
5	UMATLXXXXX	Departmental Elective II (Computing)	3	0	0	**03**	**DEC**
6	UMAPC50300	DBMS Lab	0	0	2	**01**	**PCC**
7	UMAPC50301	Lab on Scientific Computing	0	0	2	**01**	**ESC**
8	UMACS50300	OOPS with JAVA Lab	2	0	2	**03**	**SD**
		TOTAL	**17**	**2**	**6**	**22**	

Semester-VI							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	UMATC60303	Operations Research	3	1	0	**04**	**HSC**
2	UMATC60304	Complex Analysis	3	0	0	**03**	**PCC**
3	UMATC60305	Computational Topology and Data Analysis	3	0	0	**03**	**PCC**
4	UMATLXXXXX	Departmental Elective III (Mathematics)	3	0	0	**03**	**DEC**
5	UMATLXXXXX	Departmental Elective IV (Computing)	3	0	0	**03**	**DEC**
6	UMATC60306	Computational Graph Theory	3	0	0	**03**	**PCC**
7	UMAPC60302	Optimization Lab	0	0	2	**01**	**BSC**
8	UMAPR60300	Mini Project	0	0	2	**01**	**PRC**
		TOTAL	**18**	**1**	**4**	**21**	

Summer Internship – III[#]

#: The students should do at least one Summer Internship at the end of first/ second/ third year with duration of minimum 30-45 days at Institutes/Organizations/Industries and produce the certificate of completion to the department. The internship credits (2) will be added in the seventh semester.

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Semester-VII							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	UMATC70400	Functional Analysis	3	0	0	**03**	**PCC**
2	UMATC70401	Cryptography	3	0	0	**03**	**ESC**
3	UMATC70402	Advanced Scientific Computing for Engineers	3	0	0	**03**	**PCC**
4	UMATLXXXXX	Departmental Elective V (Mathematics)	3	0	0	**03**	**DEC**
5	UMATLXXXXX	Departmental Elective VI (Computing)	3	0	0	**03**	**DEC**
6	UMAPC70400	Lab on Advanced Scientific Computing	0	0	2	**01**	**PCC**
7	UMAPR70400	Project Work Part – A	0	0	8	**04**	**PRC**
8	UMAPI70400	Summer Internship#	0	0	4	**02**	**SI**
		TOTAL	15	**0**	**14**	**22**	

Semester-VIII							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Cat. Code**
1	UMATLXXXXX	Departmental Elective VII (Mathematics/Computing) (course related to Project Work)*	3	0	0	**03**	**DEC**
2	UMAPR80401	Project Work Part – B (with option of Industrial Training /Internship)	0	0	20	**10**	**PRC**
3	UMATS70400	Comprehensive Viva Voce	0	2	0	**02**	**SD**
		TOTAL	**3**	**2**	**20**	**15**	

*If the students are in Industrial training, the elective course examination related to project work may be conducted online.

Total Credits for all Eight Semesters: 164

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Departmental Electives (Mathematics)	
Sl.No	**Course Title**
1	Advanced Algebra
2	Algebraic Topology
3	Measure and Integration
4	Advanced Operations Research
5	Classical Mechanics
6	Mathematical Modeling
7	Coordinate Geometry
8	Mathematics for Biology
9	Quantum Mechanics
10	Tensor Analysis & Differential Geometry
11	Continuum Mechanics
12	Ramanujan's Theta Functions
13	Perturbation Methods
14	Spline Functions and their Applications
15	Ramanujan's Theta Functions and Applications to Number Theory
16	Lie Group Theory and Applications
17	Riemannian Geometry
18	Special Functions
19	Theory of Partitions
20	Mathematical Theory of Control
21	Wavelets
22	Advanced Differential Equations
23	Advanced Functional Analysis
24	Computational Linear Algebra
25	Boundary Layer Theory
26	Bio-fluid Mechanics
27	Advanced Fluid Mechanics
Departmental Electives (Computing)	
28	Data Structures
29	Computer Architecture
30	Design & Analysis of Algorithms
31	Numerical Solution of Differential Equations (NSDE) using Finite Difference Methods
32	Fuzzy Sets and Fuzzy logic
33	NSDE using Finite Element Method
34	Computational Fluid Dynamics
35	Multi Objective Programming

36	Theory of Automata
37	Financial Mathematics
38	NSDE using Finite Volume Method
39	Computer Graphics
40	Quantum Computing
41	Parallel Computing
42	Monte Carlo Simulation
43	Computational Biology
44	Signal Processing
45	Computational Science
46	Deep Learning
47	Advanced Computational Statistics
48	Theory of Computation
49	Elements of Data Science
50	Web Technologies
51	Data Mining
52	Cloud Computing
53	Image Processing
54	Big Data Analytics
55	Cyber Security
56	Block Chain Technologies
57	Internet of Things
58	Optimal Control Theory

*Minor Degree Specialization: Artificial Intelligence, Machine Learning and Data Science (AI, ML & DS)

Courses for Minor in AI, ML & DS							
S.No	**Course Code**	**Course Title**	**L**	**T**	**P**	**Credits**	**Offered sem**
1	UMATM50300	Advanced Mathematical Tools for Machine Learning	3	0	0	**03**	**5th**
2	UMACM50300	Data Analysis and Visualization with Python	1	0	2	**02**	**5th**
3	UMATM60301	Search Methods in Artificial Intelligence	3	0	0	**03**	**6th**
4	UMACM60301	Machine Learning in Practice	2	0	2	**03**	**6th**
5	UMATM70400	Statistics for Data Science	3	0	2	**04**	**7th**
6	UMATM70401	Multiagent Systems in AI and ML	3	0	0	**03**	**7th**
		TOTAL	**15**	**0**	**6**	**18**	

*The decision to offer the Minor Degree may be deferred for two years during which the department will assess the infrastructural and manpower provisions and other administrative support. After two years, if the situation is not favourable, the department may decide to drop the Minor Degree.

Essentials:

- The Department may suggest suitable alternative related course through MOOCs (NPTEL, SWAYAM etc.) under any category in the entire course structure based on the requirement.
- No minor degree course should be matched with the courses listed in I-VIII semesters including Departmental Electives. In case if a minor course is matching with any of the courses listed in the proposed curriculum then the Department shall suggest an alternative minor course.
- The students should take prior approval from the Department before choosing the MOOCs course.

Minor Degree (As per NEP 2020 suggested by AICTE): Artificial Intelligence, Machine Learning and Data Science (AI, ML & DS)

It is proposed to award minor degree for B. Tech students in Mathematics and Computing.

For example, a B. Tech student of Mathematics and Computing can graduate with regular degree in Mathematics and Computing and a minor in Artificial Intelligence, Machine Learning and Data Science (AI, ML & DS).

The minor degree can be awarded under the following conditions:

1. The students will be eligible to receive minor degree when they take additional courses constituting 18 credits between 5^{th} to 8^{th} semesters.
2. The minor degree courses will be over and above the B. Tech. credit requirements (164 Credits).
3. Minor degree will be allocated on merit basis on completion of 4^{th} semester. At present, the minimumCGPA 7.0 with no backlog courses may be considered for minor degree eligibility.
4. Separate grade sheets are to be issued for the courses of Minor Degree.

B. Tech. in Mathematics and Computing Course Structure from the academic year 2023-2024

Semester	Course-1	Course-2	Course-3	Course-4	Course-5	Course-6	Course-7	Course-8	L	T	P	Credits	Contact Hours
I	Calculus	Engineering Physics	Introduction to Electrical Engineering	Introduction to Computing	Multidisciplinary Course	A course on English Language	Computer Aided Engineering Graphics	-					
	5-1-0-6	3-0-0-3	3-0-0-3	2-0-2-3	3-0-0-3	2-0-0-2	0-0-2-1		18	1	4	21	23
II	Ordinary Differential Equations	A course on Chemistry/Biology/ Mechatronics /Electronics	Enumerative Combinatorics	Multidisciplinary Course	A course on English Language	A course on Environmental Sciences (Mandatory Course)	Matrix Computations	Introduction to Python Programming					
	3-1-0-4	3-0-0-3	3-0-0-3	3-0-0-3	2-0-0-2	2-0-0-2	1-0-2-2	1-0-2-2	18	1	4	21	23
III	Linear Algebra	Introduction to Number Theory	Computational Algebra	Multidisciplinary Course	A course on Indian Constitution/Essence of Indian Knowledge Tradition (Mandatory Course)	Computing Lab for Linear Algebra & Number Theory	Programming in C++	-					
	3-1-0-4	3-1-0-4	3-1-0-4	3-0-0-3	2-0-0-2	0-0-2-1	1-0-2-2		15	3	4	20	22
IV	Mathematical Methods	Introduction to Artificial Intelligence and Machine Learning	Real Analysis	Computational Statistics	Partial Differential Equations	Programming Workshop (Data Analytics using R Programming and GPU computing)	Lab on Artificial Intelligence and Machine Learning	-					
	3-1-0-4	3-0-0-3	3-1-0-4	3-1-0-4	3-1-0-4	1-0-2-2	0-0-2-1		16	4	4	22	24
V	Scientific Computing for Engineers	Fluid Mechanics	Database Management Systems (DBMS)	Departmental Elective I (Mathematics)	Departmental Elective II (Computing)	DBMS Lab	Lab on Scientific Computing	OOPS with JAVA Lab					
	3-1-0-4	3-1-0-4	3-0-0-3	3-0-0-3	3-0-0-3	0-0-2-1	0-0-2-1	2-0-2-3	17	2	6	22	25
VI	Operations Research	Complex Analysis	Computational Topology and Data Analysis	Departmental Elective III (Mathematics)	Departmental Elective IV (Computing)	Computational Graph Theory	Optimization Lab	Mini Project					
	3-1-0-4	3-0-0-3	3-0-0-3	3-0-0-3	3-0-0-3	3-0-0-3	0-0-2-1	0-0-2-1	18	1	4	21	23
VII	Functional Analysis	Cryptography	Advanced Scientific Computing for Engineers	Departmental Elective V (Mathematics)	Departmental Elective VI (Computing)	Lab on Advanced Scientific Computing	Project Work Part – A	Summer Internship					
	3-0-0-3	3-0-0-3	3-0-0-3	3-0-0-3	3-0-0-3	0-0-2-1	0-0-8-4	0-0-4-2	15	0	14	22	29
VIII	Departmental Elective VII (Mathematics/ Computing) (course related to Project Work)	Project Work Part – B	Comprehensive Viva	-									
	3-0-0-3	0-0-20-10	0-2-0-2						3	2	20	15	25
												Total Credits = 164	

Semester-I

Course Code: UMATC10100	Title of the Course: Calculus
L-T-P: 5-1-0	Credits: 6
Semester: I	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Calculate the limit and examine the continuity and understand the geometrical interpretation of differentiability.

CLO-2: Understand the consequences of various mean value theorems.

CLO-3: Understand the conceptual variations while advancing from one variable to several variables in calculus.

CLO-4: Inter-relationship amongst the line integral, double and triple integral formulations.

CLO-5: Applying Green, Gauss and Stokes' theorems in real world problems.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	2	2	2	3	2			1
CLO2	3	3	2	2	2	3	2	1		1
CLO3	3	3	3	3	2	3	2	2		1
CLO4	3	3	1	3	2	3	2	2	1	
CLO5	3	3	1	2	2	2	2		2	2

Each Course Learning Outcome (CLOs) may be mapped with one or more Program Learning Outcomes (PLOs). Write '3' in the box for 'High-level' mapping, 2 for 'Medium-level' mapping, 1 for 'Low-level' mapping.

Course Details:

Unit-I: Elementary set theory, convergence of sequences and series of real numbers, ε-δ definition of limit and continuity of a real valued function; differentiability and its geometrical interpretation, Rolle's theorem, Mean value theorem, Cauchy's mean value theorem and their geometrical interpretations, Maclaurin's and Taylor's theorems for expansion of a function, Taylor's theorem in finite form with Lagrange, Cauchy and Roche– Schlömilch forms of remainder.

Unit-II: Functions of several variables, partial differentiation, total differentiation, Euler's theorem, Taylor's theorem and generalization, maxima and minima of functions of several variables – Lagrange's method of multipliers, change of variables – Jacobians.

Unit-III: Curvature, asymptotes of general algebraic curves, parallel asymptotes, asymptotes parallel to axes, symmetry, concavity and convexity, points of inflection, tangents at origin, multiple points, position and nature of double points, tracing of Cartesian, polar and parametric curves, envelopes and evolutes, parallel asymptotes, asymptotes parallel to axes, symmetry, concavity and convexity, points of inflection, tangents at origin, multiple points, position and nature of double points, tracing of Cartesian, polar and parametric curves, envelopes and evolutes.

Unit-IV: Fundamental theorem of integral calculus and mean value theorems, Evaluation of plane areas, volume and surface area of a solid of revolution and lengths. Convergence of Improper integrals – Beta and Gamma functions – properties – differentiation under integral sign. Double and triple integrals – evaluation of surface areas and volumes – change of order of integration- change of variables in double and triple integrals.

Unit-V: Scalar and vector fields, vector differentiation, level surfaces – directional derivative - gradient of scalar field, divergence and curl of a vector field - Laplacian - line and surface integrals, Green's theorem in plane- Gauss divergence theorem- Stokes' theorem and its applications.

Course References:

1. Howard Anton, I. Bivens & Stephan Davis, Calculus (10th edition), Wiley India, 2016.
2. Gabriel Klambauer, Aspects of Calculus, Springer-Verlag, 1986.
3. Gorakh Prasad, Differential Calculus (19th edition), Pothishala Pvt. Ltd, 2016.
4. Jerrold Marsden, Anthony J. Tromba & Alan Weinstein, Basic Multivariable Calculus, Springer India Pvt. Limited, 2009.
5. James Stewart, Multivariable Calculus (7th edition), Brooks/Cole Pub Co, Cengage, 2012.
6. Walter Rudin, Principles of Mathematical Analysis, McGraw Hill Book Co, 1976.
7. Robert G. Bartle, The Elements of Real Analysis (2nd edition), John Wiley & Sons, 1976.
8. S.C. Malik, Mathematical Analysis, Wiley – Eastern, 1984.

9. R.K. Jain and S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa Publishing House, 2020.
10. Erwin Kreyszig, Advanced Engineering Mathematics (10th Edition), John Wiley and Sons.

Course Code: UMATC10101	Title of the Course: Engineering Physics
L-T-P: 3-0-0	Credits: 3
Semester: I	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Apply classical laws to various dynamic systems.

CLO-2: Applying methodologies of classical mechanics to understand rotational motion of the rigid bodies.

CLO-3: Applying principles of mechanics to understand the elastic and viscous behaviour of the systems.

CLO-4: Know the fundamentals of fluid mechanics.

CLO-5: Understanding the applications of nanomaterials.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	2	2	2	2	3	1		1
CLO2	3	3	2	2	2	2	2		2	1
CLO3	2	3	3	3	3	2	3	2	2	1
CLO4	3	3	2	3	2	3		1		
CLO5	3	3	2	1	2	3	2	3	2	2

Course Details:

Unit-I (Newtonian Mechanics): Newton's laws of motion, inertial and non-inertial systems, Simple applications of Newton's laws: Particles in equilibrium, Dynamics of particles etc., Forces of friction, Motion in one, two, and 3 dimensions: Free falling motion, Projectile motion.

Unit-II (System of Particles and Rotational Motion): Dynamics of a system of particles: Variable mass problems, Center of mass, Rigid body description, Angular velocity and angular momentum, Torque, Calculation of moment of inertia (M.I): M.I of a rectangular lamina, uniform solid sphere.

Unit-III (Elasticity and Plasticity): Stress, Strain, Hook's law, Stress and Strain diagram, Different elastic modulus and their relations, Calculation of elastic constants: Searle's method.

Unit-IV (Introduction to Fluid Mechanics, Nano and Functional Materials): Introductory definitions, Types of Fluids and their properties, Archimedes' principle, Surface tension, Pressure difference: surface film and contact angle, capillarity; Fluid dynamics: Equations of continuity, Bernoulli's equation and its applications, Viscosity, Poiseuille's law, Stoke's law, Reynolds number. History and classification of nanomaterials, Properties and applications of nanomaterials, Fabrication techniques: Physical methods. Functional materials: Introduction, Classification, Properties, Applications.

Course References:

1) An introduction to Mechanics, D Klepner and R. Kolenkow (Cambridge University Press).
2) Mechanics, D. S. Mathur (S.Chand & Co.).
3) R. K. Bansal, Fluid Mechanics and Hydraulic Machines (Lakshmi Publications)
4) University Physics, FW Sears, MW Zemansky & HD Young 13/e, 1986 (Addison-Wesley).
5) Mechanics Berkeley Physics course, vol. 1, Charles Kittel, et. al, 2007 (Tata McGraw-Hill).
6) Physics, Resnick, Halliday & Walker 9/e, 2010 (Wiley).
7) Engineering Mechanics, Basudeb Bhattacharya, 2nd edt. 2015 (Oxford University Press).
8) University Physics, Ronald Lane Reese, 2003 (Thomson Brooks/Cole).
9) Functional Materials Preparation, Processing and Applications, S. Banerjee, A.K. Tyagi, 1st edit (Elsevier).

Course Code: UMATC10102	Title of the Course: Introduction to Electrical Engineering
L-T-P: 3-0-0	Credits: 3
Semester: I	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Apply basic laws and analyze electrical circuits.

CLO-2: Understand transformer working principle and its usage.

CLO-3: Understand electrical machines working principle and their applications.

CLO-4: Understand LT and domestic electrical safety, wiring and different measuring instruments and their use.

CLO-5: Know the computing applications in Electrical Engineering.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	2	2	2	2	2	1		1
CLO2	3	3	2	2	2	2	2		2	1
CLO3	3	3	2	3	3	2	3	2	2	1
CLO4	3	3	2	3	2	3	2	1		
CLO5	3	3	3	1	2	3	2	2	2	2

Course Details:

Unit-I: Electrical circuit elements (R, L and C), voltage and current sources, Kirchhoff current and voltage laws, analysis of simple circuits with dc excitation. Superposition, Thevenin and Norton Theorems. Time-domain analysis of first-order RL and RC circuits. Representation of sinusoidal waveforms, peak and rms values, phasor representation, real power, reactive power, apparent power, power factor. Analysis of single-phase ac circuits consisting of R, L, C, RL, RC, RLC combinations (series and parallel), resonance. Three-phase balanced circuits, voltage and current relations in star and delta connections.

Unit-II: Magnetic materials, BH characteristics, series and parallel magnetic circuits, ideal and practical transformer, equivalent circuit, losses in transformers, regulation and efficiency. Autotransformer and three-phase transformer connections.

Unit-III: Generation of rotating magnetic fields, Construction and working of a three-phase induction motor, Significance of torque-slip characteristic, loss components, efficiency and applications. Construction, working, torque-speed characteristic and applications of separately excited dc motor. Construction and working of synchronous generators.

Unit-IV: Components of LT Switchgear: Switch Fuse Unit (SFU), MCB, ELCB, MCCB, Types of Wires and Cables, Earthing. Types of Batteries, Important Characteristics for Batteries. Elementary calculations

for energy consumption, power factor improvement and battery backup. Lamps-fluorescent, CFL, LED. Electrical measuring instruments principle and applications- energy meter, megger, tong tester. Electrical Wiring. Computing applications in Electrical Engineering.

Course References:

1. Fitzgerald, D. E. Higginbotham, A. Grabel, Basic Electrical Engineering, 5th Edition, McGraw-Hill, 2009.
2. William H. Hayt Jr. , Jack E. Kemmerly, Steven M. Durbin, Engineering Circuit Analysis, 6th Edition,TMH, 2002.
3. Olle I. Elgerd, Basic Electric Power Engineering, Addison-Wesley, 1977. Edward Hughes, Electrical Technology,7th Edition, Longman, 1995.
4. Basic Electrical Engineering - D.P. Kothari and I.J. Nagrath, 3rd edition 2010, Tata McGraw Hill.
5. L.S. Bobrow, Fundamentals of Electrical Engineering", Oxford University Press, 2011.
6. Electrical and Electronics Technology, E. Hughes, 10th Edition, Pearson, 2010.

Course Code: UMACC10100	Title of the Course: Introduction to Computing
L-T-P: 2-0-2	Credits: 3
Semester: I	Type of the Course: Theory cum Practical

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Understand the use of input, output functions and structure of C program.

CLO-2: Write the programs using control statements in C.

CLO-3: Write the programs using loop statements in C.

CLO-4: Handle operations like searching, insertion, deletion, and traversing mechanism etc. on various data structures.

CLO-5: Use linear and non-linear data structures like stacks, queues, linked list etc.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1		1		2		3		1		
CLO2	3			2					2	3
CLO3		2	1		2		1	2		

CLO4	1			3			2		1	
CLO5		2				2		2	1	

Course Details:

Unit-I (Introduction to Computing and C++ Programming Fundamentals): Introduction to Computing-Computational Software-Programming Languages, Open source software Vs. Commercial software. Introduction to C++ Programming-Data Types – Variables – Operations – Expressions and Statements – Conditional Statements – Functions – Recursive Functions – Arrays – Single and Multi-Dimensional Arrays.

Unit-II (C++ Programming-Advanced Features): Structures – Union – Enumerated Data Types – Pointers: Pointers to Variables, Arrays and Functions – File Handling – Preprocessor Directives. Practice the programs on the concepts covered in Units I & II.

Unit-III (Linear and Non-Linear Data Structures): Abstract Data Types (ADTs) – List ADT – Array-Based Implementation – Linked List – Doubly- Linked Lists – Circular Linked List – Stack ADT – Implementation of Stack – Applications – Queue ADT – Priority Queues – Queue Implementation – Applications. Trees – Binary Trees – Tree Traversals – Expression Trees – Binary Search Tree – Hashing – Hash Functions – Separate Chaining – Open Addressing – Linear Probing– Quadratic Probing – Double Hashing – Rehashing. Practice the programs on the concepts covered in Units III & IV.

Unit-IV (Sorting and Searching Techniques): Insertion Sort – Quick Sort – Heap Sort – Merge Sort – Linear Search – Binary Search. Practice the programs on sorting and searching techniques.

Course References:

1. Brian W. Kernighan, Rob Pike, “The Practice of Programming”, Pearson Education, 1999.

2. Shah Yi, Mh Thaker, “Programming In C++”, First Edition, USA ISTE, 2002.

3. Stanley B. Lippman, Josée Lajoie and Barbara E. Moo, “C++ Primer”, Fifth Edition,O’Reilly, 2013.

4. Alfred V. Aho, John E. Hopcroft, Jeffrey D. Ullman, “Data Structures and Algorithms”, Pearson Education,1983.

5. E. Balaguruswamy, “C and Data Structures”, 4th Edition, Tata Mc Graw Hill.

6. The C++ Programming Language (4th Edition) By Bjarne Stroustrup.

Course Code: XXXXXXXXXX	*Title of the Course: Multidisciplinary Course
L-T-P: 3-0-0	Credits: 3
Semester: I	Type of the Course: Theory

*The students have the flexibility to choose a course related to interdisciplinary (multidisciplinary) from other Departments or through Massive Open Online Courses (MOOC's) NPTEL, SWAYAM etc. based on their choice. Accordingly, the course code may be given. However, the MOOC's course must be approved by the Department.

Course Code: UMATA10100	*Title of the Course: A course on English Language
L-T-P: 2-0-0	Credits: 2
Semester: I	Type of the Course: Theory

*The Department may decide to choose a course related to the English Language from the Department of English or through Massive Open Online Courses (MOOC's) NPTEL, SWAYAM etc. based on the requirement. Accordingly, the course code may change if it is needed.

Course Code: UMAPC10100	Title of the Course: Computer Aided Engineering Graphics
L-T-P: 0-0-2	Credits: 1
Semester: I	Type of the Course: Practical

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Understand the points with all quadrant systems.

CLO-2: Understand the lines drawing in first quadrant systems.

CLO-3: Apply the concepts of planes to draw the projections.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	2	2	3	2	1	3	2	1		
CLO2	2	2	2	2		2	2			
CLO3	2	2	3	2	2	1	1	2		

Course Details:

Unit-I (Introduction to Computer Aided Sketching): Drawing Instruments and their uses, BIS conventions, Lettering, Dimensioning and free hand practicing. Introduction to Solid Edge standard toolbar/menus. Co-ordinate system, points, axes, poly-lines, square, rectangle, polygons, splines, circles, ellipse, text, move, copy, off-set, mirror, rotate, trim, extend, break, chamfer, fillet, curves, constraints viz. tangency, parallelism, inclination and perpendicularity. Dimensioning conventions.

Unit-II (Orthographic Projections): Projections of points, Projections of straight lines (First Angle Projection), True and apparent lengths and Projections of plane surfaces.

Course References:

1. Bhatt N.D., Panchal V.M. & Ingle P.R. (2014), Engineering Drawing, Charotar Publishing House.
2. A Primer on Computer Aided Engineering Drawing-2006, Published by VTU, Belgaum.
3. Fundamentals of Engineering Drawing with an Introduction to Interactive Computer
4. Graphics for Design and Production- by Luzadder Warren J., Duff John M., Eastern Economy
5. Edition, 2005- Prentice Hall of India Pvt. Ltd., New Delhi.
6. Engineering Graphics by K.R. Gopalakrishna, 32nd edition, 2005- Subash Publishers Bangalore.

7.Shah, M.B. & Rana B.C. (2008), Engineering Drawing and Computer Graphics, Pearson Education

8. Agrawal B. & Agrawal C.M. (2012), Engineering Graphics, TMH Publication
9. Engineering Graphics & Design, A.P. Gautam & Pradeep Jain Khanna Publishing House
10. Narayana, K.L. & P Kannaiah (2008), Text book on Engineering Drawing, Scitech Publishers. (Corresponding set of) CAD Software Theory and User Manuals.
11. https://nptel.ac.in/courses/112/103/112103019/# (online resource)

Semester-II

Course Code: UMATC20103	Title of the Course: Ordinary Differential Equations
L-T-P: 3-1-0	Credits: 4
Semester: II	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Understand the origin of ordinary differential equations.

CLO-2: Learn various techniques for getting exact solutions of solvable first-order and linear differential equations of higher order theoretically and computationally.

CLO-3: Apply the Picard's and Power series concepts to resolve the first and higher-order linear differential equations.

CLO-4: Solve arbitrary order differential equations using various methods and computing techniques.

CLO-5: Apply the ordinary differential equations to resolve the day-to-day problems arising in physical, chemical, biological, and other disciplines.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	2							
CLO2	3	3	2	2						
CLO3			3	3				2		
CLO4				3	2	3				
CLO5							2		2	2

Course Details:

Unit-I: Basic concepts and genesis of ordinary differential equations, Equations in which variables are separable, Homogeneous equations, Exact differential equations, Linear differential equations, and equations reducible to linear form, First-order higher degree equations solvable for x, y and p. Clairaut's form and singular solutions. Statement of Picard's theorem for the existence and uniqueness of the solutions of the first-order differential equations. Applications of First order differential equations.

Unit-II: Statement of existence and uniqueness theorem for linear differential equations, General theory of linear differential equations of second order with variable coefficients, Solutions of homogeneous linear ordinary differential equations of second order with constant coefficients, Transformations of the equation by changing the dependent/independent variable, Method of variation of parameters and method of undetermined coefficients, Reduction of order, Coupled linear differential equations with constant coefficients, autonomous system. Applications.

Unit-III: Principle of superposition for a homogeneous linear differential equation, Linearly dependent and linearly independent solutions on an interval, Wronskian and its properties, Concept of a general solution of a linear differential equation, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler-Cauchy equation, Method of variation of parameters and method of undetermined coefficients, Inverse operator method, Sturm-Liouville problems. Applications of higher-order linear differential equations.

Unit-IV: Power series method, Frobenius method, Legendre's equation, Legendre polynomials, Rodrigue's formula, Orthogonality of Legendre polynomials, Bessel's equation, Bessel function of first and second kinds, error functions and their properties, Recurrence relations. Applications.

Course References:

1. George F. Simmons, *Differential Equations with Applications and Historical Notes* (3rd edition), CRC Press, Taylor & Francis, 2017.
2. Shepley L. Ross, *Differential Equations* (3rd edition), Wiley India, 2007.
3. E.A. Coddington, *An Introduction to Ordinary Differential Equations*, PHI Learning, 1999.
4. U. Tyn Myint, *Ordinary Differential Equations*, Elesvier North- Holland, 1978.
5. E.D. Rainville and P.E. Bedient, *Elementary Differential Equations*, McGraw Hill, NewYork, 1969.
6. E.A. Coddington and N. Levinson, *Theory of ordinary differential equations*, McGraw Hill, 1955.
7. A.C. King, J. Billingham and S. R. Otto, *Differential equations*, Cambridge University Press, 2006.
8. S.L. Ross, *Differential equations*, 3rd edition, John Wiley & Sons, New York, 1984.
9. Erwin Kreyszig, *Advanced Engineering Mathematics* (10th edition). Wiley, 2011.
10. Daniel A. Murray, *Introductory Course in Differential Equations*, Orient, 2003.

Course Code: UMATC20104	***Title of the Course: A course on Chemistry/Biology/Mechatronics/Electronics**
L-T-P: 3-0-0	**Credits: 3**
Semester: II	**Type of the Course: Theory**

*The Department may decide to choose a course related to Chemistry/Biology/Mechatronics/Electronics from allied Science and Engineering Departments or through Massive Open Online Courses (MOOC's) NPTEL, SWAYAM etc. based on the requirement. Accordingly, the course code may change if it is needed.

Course Code: UMATC20105	Title of the Course: Enumerative Combinatorics (Mathematical Foundations for Computer Science)
L-T-P: 3-0-0	Credits: 3
Semester: II	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course, the student will be able to

CLO-1: Apply propositional logic and first-order logic to solve problems. Also, determine if a logical argument is valid or invalid.

CLO-2: Construct induction proofs involving summations, inequalities, and divisibility arguments. Also, implement the principles of counting, permutations, and combinatory to solve real-world problems.

CLO-3: Formulate and solve recurrence relations. Prove whether a given relation is an equivalence relation/poset and will be able to draw a Hasse diagram.

CLO-4: Develop and analyze the concepts of Boolean algebra

CLO-5: Develop and analyze the concepts of graph theory.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	2	2	2			1				
CLO2	2	3	3	1	2	1				
CLO3	3	3	2	1	3	3	2	1		
CLO4	2	3	3	1	2	3				
CLO5	3	2	3	1	2	2		1		

Course Details:

Unit-I: Combinations of sets, Finite and Infinite sets, uncountable infinite sets, the principle of inclusion and exclusion, mathematical induction. Propositions, fundamentals of logic, first-order logic, ordered sets. Two Basics of counting principles, Pigeonhole principle, Permutations, and combinations, Pascal's Identity, Vandermonde's Identity, Generalized Permutations, and combinations.

Unit-II: Coefficients of generating functions, applications of generating functions, Solving Recurrence Relations- Linear Homogeneous and Non- Homogeneous Recurrence relations, solution by the method of generating functions, sorting algorithm. Relations and functions: properties of binary relations, equivalence relations, and partitions, partial and total ordering relations, Transitive closure, and Warshal's algorithm.

Unit-III: Chains, Lattices, and algebraic systems, the principle of duality, basic properties of algebraic systems, distributive and complemented lattices, Boolean lattices and algebras, uniqueness of finite Boolean algebras, Boolean expressions, and functions.

Unit-IV: Graphs and planar graphs, multigraphs and weighted graphs, Trees and cut sets. Applications of Graph Theory.

Course References:

1. J. R. Mott, A. Kandel and Baker (2006), Discrete Mathematics for Computer Scientists, PHI.
2. C. L. Liu (1985), Elements of Discrete Mathematics, McGraw Hill.
3. J. P. Tremblay and R. Manohar (2004), Discrete Mathematical Structures with applications to Computer Science, McGraw Hill Book Co.

Course Code: XXXXXXXXXX	*Title of the Course: Multidisciplinary Course
L-T-P: 3-0-0	Credits: 3
Semester: II	Type of the Course: Theory

*The students have the flexibility to choose a course related to interdisciplinary (multidisciplinary) from other Departments or through Massive Open Online Courses (MOOC's) NPTEL, SWAYAM etc. based on their choice. Accordingly, the course code may be given. However, the MOOC's course must be approved by the Department.

Course Code: UMATA20101	*Title of the Course: A course on English Language
L-T-P: 2-0-0	Credits: 2
Semester: II	Type of the Course: Theory

*The Department may decide to choose a course related to the English Language from the Department of English or through Massive Open Online Courses (MOOC's) NPTEL, SWAYAM etc. based on the requirement. Accordingly, the course code may change if it is needed.

Course Code: XXXXXXXXXX	*Title of the Course: A course on Environmental Sciences (Mandatory Course)
L-T-P: 2-0-0	Credits: 2
Semester: II	Type of the Course: Theory

*The Department may decide to choose a course related to Environmental Sciences offered by the University or through Massive Open Online Courses (MOOC's) NPTEL, SWAYAM etc. based on the requirement. Accordingly, the course code may be given.

Course Code: UMACC20101	Title of the Course: Matrix Computations
L-T-P: 1-0-2	Credits: 2
Semester: II	Type of the Course: Theory cum Practical

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Understand the basic matrix operations and solutions of matrices using various methods. Learn the basics of Matlab software and its operation.

CLO-2: Solve the matrix and other problems using Matlab.

CLO-3: Apply Matlab programming knowledge to solve real-life problems.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	3		2					
CLO2	3	2	3	3			2			
CLO3	3	3	3			3		2		

Detailed Syllabus:

Unit-I: Introduction to matrices, the rank of a matrix, invariance of rank under elementary transformations. Reduction to standard forms (Gauss Elimination, Gauss-Jordan and LU Decomposition), solutions of linear homogeneous and non-homogeneous equations.

Unit-II: Complex matrices and types of complex matrices, characteristic polynomial; Eigenvalues, Eigenvectors and their properties, Cayley-Hamilton theorem and its applications, minimal polynomial, Diagonalization of a matrix.

Unit-III: Introduction to Matlab, plotting and visualization, solutions of the matrix and other problems/methods covered in Units- I & II using Matlab Programming. Explanations of some real-life applications of Mathematics using Matlab Programming.

Course References:

1. A.I. Kostrikin, Introduction to Algebra, Springer Verlag, 1984.
2. S. H. Friedberg, A. L. Insel and L. E. Spence, Linear Algebra, Prentice Hall of India Pvt. Ltd., New Delhi, 2004.
3. Richard Bronson, Theory and Problems of Matrix Operations, Tata McGraw Hill, 1989.
4. Frank Ayres, Jr., Theory and Problems of Matrices, Schaum's Outline Series, 1989.
5. Rudra Pratap, Getting Started with Matlab, A quick introduction for Scientists and Engineers, Oxford University Press, 2019.
6. Raj Kumar Bansal, Ashok Kumar Goel, Manoj Kumar Sharma, Matlab and its Applications in Engineering, Pearson Education India, 2009.
7. Amos Gilat, Matlab, An introduction with applications, 4th Edition, Wiley, 2011.
8. Misza Kalechman, Practical Matlab Applications for Engineers, City University of New York, CRC Press, 2009.

Course Code: UMACS20100	Title of the Course: Introduction to Python Programming
L-T-P: 1-0-2	Credits: 2
Semester: II	Type of the Course: Theory cum Practical

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Understand the basics of Python programming, including variables, data types, operators, control flow, functions, and modules.

CLO-2: Develop problem-solving skills using Python.

CLO-3: Use Python to analyze data and create visualizations.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	2	2	2	3	3	1		
CLO2	3	3	2	2	2	3	3		2	3
CLO3	3	3	2	1	3	3	3	2		

Course Details:

Unit-I (Introduction to Python, Conditionals & Loops): From processors to programming, high level and low level languages, compiled and interpreted languages, evolution of python, introduction to VSCode, introduction to Google Colab, Python variables, Python basic operators, Python data types, variables, declaring and using numeric data types: int, float etc., basic input-output operations, Boolean values, if, else and else if, Simple for loops in python, for loop using ranges, string, list and dictionaries, use of while loops in python, loop manipulation using pass, continue, break and else. Practice the programs on conditional statements and loops.

Unit-II (Strings, Lists and Functions): Assigning values in strings, string manipulations, string special operators, string formatting operators, triple quotes, raw string, unicode string, build-in-string methods, lists introduction, accessing values in list, list manipulations, list operations, indexing, slicing & matrices, use of tuple data type string, list and dictionary, string manipulation methods, programming using string, list and dictionary in-built functions, built-in functions and methods, functions, writing functions in Python, returning a result from a function, pass by value & pass by reference, function arguments & its types, recursive functions, file reading and writing. Practice the programs on strings, lists and functions.

Unit-III (Python Packages): Simple programs using the built-in functions of packages like Plotting with matplotlib - histograms, graphs, heatmaps, contour plots etc., basic statistical analysis with numpy and pandas, data reduction and filtering.

Course References:

1. Introduction to Python Programming, William Mitchell, Povel Solin, Martin Novak et al., NCLab Public Computing, 2012.
2. Introduction to Python Programming, ©Jacob Fredslund, 2007.
3. An Introduction to Python, John C. Lusth, The University of Alabama, 2011.
4. Introduction to Python, ©Dave Kuhlman, 2008.
5. Python for Data Analysis by Wes McKinney
6. Mastering python for data science, Samir Madhavan
7. A. B. Downey, Think Python, 2e: How to Think Like a Computer Scientist, O'Reilly, 2015.
8. Arockia Mary P, Problem Solving and Python Programming, Shanlax Publications, 2021.
9. Python: The Hard Way by Zed Shaw
10. C. Morris, "https://www.kaggle.com/learn/python," [Online Resource].
11. "https://docs.python.org/3/tutorial/index.html," [Online Resource].

Semester-III

Course Code: UMATC30200	Title of the Course: Linear Algebra
L-T-P: 3-1-0	Credits: 4
Semester: III	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Understand the concepts of the terms span, linear independence, basis, and dimension, and apply these concepts to various vector spaces and subspaces.
CLO-2: Apply the concept of vector spaces using linear transforms, which is used in computer graphics and inner product spaces.
CLO-3: Solve problems in different areas of science and engineering.
CLO-4: Identify the importance of orthogonal property in spectral theory.
CLO-5: Apply the knowledge of linear algebra to resolve real-world problems.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	2	2							
CLO2	3	2	2	2						
CLO3			3	3	1			2		
CLO4			2		2	2				
CLO5							3	2	3	2

Course Details:

Unit-I: Vector spaces, subspaces, linear combination, span, linear dependence and independence, basis, dimension, finite-dimensional vector space.

Unit-II: Linear transformations, basic properties, invertible linear transformation, matrices of linear Transformations, vector space of linear transformations, change of bases, similarity, applications.

Unit-III: Linear functional and adjoints, Hermitian, self-adjoint, unitary and normal operators, Spectral Theorem for normal operators. Inner product spaces, Gram-Schmidt orthonormalization, orthogonal projections.

Unit-IV: Bilinear forms, symmetric and skew-symmetric bilinear forms, quadratic forms, reduction of a quadratic form to a canonical form, classification of quadratic forms, Sylvester's law of inertia and applications.

Course References:

1. K. Hoffman and R. Kunze (2003), Linear Algebra, Prentice Hall of India, New Delhi.
2. M. Artin (1994), Algebra, Prentice Hall of India.
3. S. Kumeresan (2000), Linear Algebra, A Geometric approach, Prentice Hall India.
4. A.R. Vasishtha and A. K. Vasishtha (2004), Matrices, Krishna's educational publishers.
5. I. N. Herstein (1964), Topics in Algebra, Vikas Publishing House, New Delhi.
6. K.B. Datta (2006), Matrix and Linear Algebra, Prentice Hall of India, New Delhi.
7. L. Lipschutz and M. Lipson, Linear Algebra, McGraw Hill Education, India.

Course Code: UMATC30201	Title of the Course: Introduction to Number Theory
L-T-P: 3-1-0	Credits: 4
Semester: III	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Learn methods and techniques used in number theory and communicate effectively in both written and oral form.

CLO-2: Know about open problems in number theory, namely, the Goldbach conjecture and twin prime conjecture.

CLO-3: Demonstrate a basic understanding of number theoretic functions including Euler's Φ function and the Mobius μ-function.

CLO-4: Apply public cryptosystems, in particular, RSA.

CLO-5: Apply the Law of Quadratic Reciprocity and other methods to classify numbers as primitive roots, quadratic residues, and quadratic non-residues.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	2	3	1	2	1	2	3		
CLO2	3	2	3	2	3	2	2	2		
CLO3	3	2	3	1	3	1	2	1		
CLO4	3	3	2	2	1	1	2	1		
CLO5	3	2	1	2	1	1	2	1		

Course Details:

Unit-I: Division algorithm, Euclid's algorithm, prime numbers, fundamental theorem of arithmetic, distribution of primes, discussion of the Prime Number Theorem, the series of Reciprocals of primes, congruences, Goldbach conjecture, Twin-prime conjecture, Linear Congruence, Chinese remainder theorem, Fermat's little theorem, Wilson's theorem, Euler's theorem.

Unit-II: Elementary arithmetical functions, perfect numbers, Mersenne primes, and Fermat numbers, Irrational Numbers-Irrationality of the mth root of N, e, and π.

Unit-III: Primitive roots and indices, Quadratic residues, Legendre symbol, Gauss's Lemma, Quadratic reciprocity law, Jacobi symbol.

Unit-IV: Fermat's two square theorems, Lagrange's four-square theorem, Diophantine equations: $ax + by = c$, $x^2 + y^2 = z^2$, $x^4 + y^4 = z^4$, sums of two and four squares. Applications: Public key encryption, RSA encryption, and decryption with applications in security systems.

Course References:

1. D.M. Burton (2010), Elementary Number Theory, 7th Edition. McGraw-Hill Education.
2. G.H. Hardy and E.M. Wright (1975), An introduction to the Theory of Numbers, 4th Edition. Oxford University Press.
3. I. Niven, H. S. Zuckerman and H. L. Montgomery (2004), An Introduction to the Theory of Numbers, New York, John Wiley and Sons, Inc., 5thEd.
4. T. M. Apostol (1998), Introduction to Analytic Number Theory, Narosa Publishing House, New Delhi.
5. W.W. Adams and L.J. Goldstein (1972), Introduction to the Theory of Numbers, 3rd ed., Wiley Eastern. Neal Koblitz (1994). A Course in Number Theory and Cryptography (2nd edition). Springer-Verlag.
6. A. Baker (1984), A Concise Introduction to the Theory of Numbers, Cambridge University Press, Cambridge.

Course Code: UMATC30202	Title of the Course: Computational Algebra
L-T-P: 3-1-0	Credits: 4
Semester: III	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Apply the knowledge of Algebra to attain good mathematical maturity and enables to build mathematical thinking and skill.

CLO-2: Understand the concepts of homomorphism and isomorphism between groups.

CLO-3: Apply class equations and Sylow theorems to compute different problems.

CLO-4: Explore the properties of the principle ideal domain, Euclidean domain, Unique

factorization domain, polynomial rings, and field extensions.

CLO-5: Design, analyze, and implement the concepts of Gauss Lemma, Einstein's irreducibility criterion, etc.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	2	2	2	2	1	1	1			
CLO2	2	3	2	1	3	2	2			
CLO3	1	2	3	1	3	3	1			
CLO4	2	1	2	2	3	2	1			
CLO5	1	1	2	2	2	2				

Course Details:

Unit-I: Groups, subgroups, normal subgroups, quotient groups, cyclic groups, permutation groups, cosets and Lagrange's theorem, Group homomorphisms, Automorphisms, Isomorphisms, Fundamental theorems of group homomorphisms, Cayley's Theorem.

Unit-II: Class equations, Sylow theorems, Direct Products, Fundamental Theorem of Finite Abelian groups.

Unit-III: Rings, introduction to fields, ideals, prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain.

Unit-IV: Polynomial rings and irreducibility criteria. Computing the group and ring theory problems in real life.

Course References:

1. G. A. Gallian (2013), Contemporary Abstract Algebra, Narosa Publishers.
2. I. N. Herstein (1975), Topics in Abstract Algebra, Wiley Eastern Limited.
3. D. S. Dummit, R. M. Foote (1999), Abstract Algebra, Second Edition, John Wiley & Sons, Inc.
4. Surjeet Singh and Qazi Zameeruddin (1994), Modern Algebra, Vikas Publishing House.
5. N. Jacobson (2009), Basic Algebra-I, 2nd ed., Dover Publications.

6. Darek F. Holt, Bettina Eick and Eamonaa. Obrien. (2005), Handbook of computational group theory, Chapman & Hall/CRC Press.
7. J. B. Fraleigh (2002), A first course in abstract algebra, 7th ed., Addison-Wesley Longman.

Course Code: XXXXXXXXXX	*Title of the Course: Multidisciplinary Course
L-T-P: 3-0-0	Credits: 3
Semester: III	Type of the Course: Theory

*The students have the flexibility to choose a course related to interdisciplinary (multidisciplinary) from other Departments or through Massive Open Online Courses (MOOC's) NPTEL, SWAYAM etc. based on their choice. Accordingly, the course code may be given. However, the MOOC's course must be approved by the Department.

Course Code: XXXXXXXXXX	*Title of the Course: A course on Indian Constitution/Essence of Indian Knowledge Tradition (Mandatory Course)
L-T-P: 2-0-0	Credits: 2
Semester: III	Type of the Course: Theory

*The Department may decide to choose a course related to Indian Constitution/Essence of Indian Knowledge Tradition offered by the University or through Massive Open Online Courses (MOOC's) NPTEL, SWAYAM etc. based on the requirement. Accordingly, the course code may be given.

Course Code: UMAPC30200	Title of the Course: Computing Lab for Linear Algebra & Number Theory
L-T-P: 0-0-2	Credits: 1
Semester: III	Type of the Course: Practical

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Understand the fundamental computing operations in linear algebra and number theory.

CLO-2: Create, select, and apply appropriate techniques, resources, and modeling to complex engineering problems with an understanding of the limitations.

CLO-3: Apply the knowledge of mathematics and computing to solve real world problems.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	2	3	2	2	2	2	1	2		
CLO2	3	3	1	2	2	2	1	2		
CLO3	2	3	1	2	2	2	1	2		

Course Details:

Unit-I: Practice on solving linear systems, linear combination of vectors, spanning set of a vector space, linearly independent set of vectors, basis for a vector space, investigate properties of the null space of a matrix, finding the basis of null-space of a matrix, properties of row and column spaces and finding the basis of them, inconsistent linear system, orthogonal projections, normal equation, polynomial interpolation using Matlab/Python.

Unit-II Practice on elementary Operations in number theory, Integer, and polynomial arithmetic, Euclidean algorithm, and continued fractions, Modular Arithmetic, Fermat's theorem, Chinese Remainder Theorem, Primality testing, Integer factorization and number theoretic functions using Matlab/Maple/Python.

Course References:

1. Rudra Pratap, Getting Started with Matlab, A quick introduction for Scientists and Engineers, Oxford University Press, 2019.
2. Raj Kumar Bansal, Ashok Kumar Goel, Manoj Kumar Sharma, Matlab and its Applications in Engineering, Pearson Education India, 2009.
3. Amos Gilat, Matlab, An introduction with applications, 4th Edition, Wiley, 2011.
4. Misza Kalechman, Practical Matlab Applications for Engineers, City University of New York, CRC Press, 2009.
5. Fausett L.V. , Applied Numerical Analysis Using MATLAB, 2nd Ed., Pearson Education, 2007.
6. https://in.mathworks.com/help/symbolic/number-theory-1.html (Online Resource)
7. Cleve Moler, Experiments with MATLAB, Electronic edition published by MathWorks, Inc., 2011.
8. Jessica Leung and Dmytro Matsypura, Python Language Companion to Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares, 2020.
9. Archana Jadhav, Nandani Sakhare, Linear Algebra Using Python, Himalaya Publishing House Pvt. Ltd., 2018.
10. Jeffrey Hoffstein, Jill Pipher, and Joseph Silverman An Introduction to Mathematical Cryptography, 2nd Edition, Springer, 2014.

Course Code: UMACC30200	Title of the Course: Programming in C++ with OOPs
L-T-P: 1-0-2	Credits: 2
Semester: III	Type of the Course: Theory cum Practical

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Implement programs using classes and objects. Also, ability to develop applications for physical applications using OOP techniques.

CLO-2: Able to understand the overloading concept. Also, specify the forms of inheritance and use them in programs.

CLO-3: Analyze polymorphic behavior of objects. Also, understand virtual functions and polymorphism.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	2	3	2	1	3	3	2	2	2
CLO2	2	1	3	3	2	1	2	1	1	-
CLO3	3	1	3	2	1	2	-	-	-	-

Course Details:

Unit-I (Basic concepts of C++, Classes and Objects): Concept of C++; Object oriented languages – Applications of OOP, C++ Program with class-Nesting of member functions-private member functions-Arrays within a class- memory allocation for objects-Static data members-Arrays of objects-objects as Function arguments - Friend functions, inline function, Returning objects. Practice the C++ programs on nesting of member functions, memory allocation for objects, objects as function arguments, friend functions and inline functions.

Unit-II (Constructors, Destructors and Overloading): Multiple constructors in class-Constructors with default arguments copy constructor-Dynamic constructors; Overloading unary operators-overloading binary operators-overloading binary operators using Friends - Rules for overloading operators – function overloading, Type conversions. Practice the C++ programs on constructors with default arguments, copy and dynamic constructors, overloading unary and binary operators, function overloading and type conversions.

Unit-III (Inheritance): Defining derived classes-Single inheritance - Multilevel inheritance – Multiple inheritance - Hierarchical inheritance -Virtual base classes – Abstract classes, Pointers, Virtual functions and Polymorphism. Practice the C++ programs on single, multilevel, multiple and hierarchical inheritance, virtual base and abstract classes.

Course References:

1. Object-Oriented Programming in C++, Robert Lafore, Sams, 2001, Fourth Edition.
2. Object oriented programming with C++, E. Balaguruswamy, Tata McGraw Hill, 2008, Fourth Edition.
3. Object-Oriented programming in C++, Barkakati Nabajyoti, PHI, 1991.
4. The C++ Programming Language, Stroustroup Bjarne, Addison-Wesley,1991.

Semester-IV

Course Code: UMATC40203	Title of the Course: Mathematical Methods
L-T-P: 3-1-0	Credits: 4
Semester: IV	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Gain knowledge of a wide range of mathematical techniques and application of mathematical methods/tools in other scientific and engineering domains.

CLO-2: Know the connections between the mathematical series and other scientific and humoristic disciplines.

CLO-3: Apply principles of mathematical reasoning and their use in understanding, analyzing and developing formal arguments.

CLO-4: Use Fourier series, Laplace transform and Z-transform.

CLO-5: Learn how to expand a function in a Fourier series, and under what conditions such an expansion is valid. They will be aware of the connection between this and integral transforms (Fourier and Laplace) and be able to use the latter to solve mathematical problems relevant to the physical sciences.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO-1	2	3	3	2	2	1	-	1	2	1
CLO-2	2	3	2	1	2	1	-	1	3	1
CLO-3	2	3	2	2	1	1	1	1	3	1
CLO-4	2	3	2	1	2	1	-	1	3	1
CLO-5	2	3	2	1	2	1	-	1	3	1

Detailed Syllabus:

Unit-I: Introduction to Laplace transform, Laplace of some standard functions, Existence conditions for the Laplace Transform, Shifting theorems, Laplace transform of derivatives and integrals, Inverse Laplace transform and their properties, Convolution theorem, Initial and final value theorem, Laplace transform of periodic functions, error functions, Heaviside unit step function and Dirac delta function, Applications of Laplace transform to solve ODEs, Finite Laplace Transform: Definition and properties, Shifting and scaling theorem.

Unit-II: Introduction to Fourier series, Trigonometric Fourier series and its convergence. Fourier series of even and odd functions, Gibbs phenomenon, Fourier half-range series, Parseval's identity, Complex form of Fourier series.

Unit-III: Introduction to Fourier Transforms, Fourier integrals, Fourier sine and cosine integrals, Complex form of Fourier integral representation, Fourier transform, Fourier transform of derivatives and integrals, Fourier sine and cosine transforms and their properties, Convolution theorem, Application of Fourier transforms to Boundary Value Problems.

Unit-IV: Introduction to Z–transform, inverse Z-transform of elementary functions, Shifting theorems, Convolution theorem, Initial and final value theorem, Application of Z-transforms to solve difference equations, Hankel Transform: Basic properties of Hankel Transform, Hankel Transform of derivatives, Mellin Transform: Definition and properties of Mellin transform, Shifting and scaling properties, Mellin transforms of derivatives and integrals, Applications of Mellin transform.

Course References:

1. Kreyszig, E., "Advanced Engineering Mathematics", John Wiley & Sons, 2011.

2. Jain, R.K. and Iyengar, S.R.K., "Advanced Engineering Mathematics", Narosa Publishing House, 2019, 5th Edition.

3. Hildebrand F. B., "Methods of Applied Mathematics", Courier Dover Publications, 1992.

4. Debanth L. and Bhatta D., Integral Tranforms and Their Applications, 2nd edition, Taylor and Francis Group, 2007.

5. Hwei p. hsu., “Schaum's outlines of theory and problems of signals and systems”.

6. Murray r. Spiegel., “Schaum's outline of theory and problems of Laplace transforms”.

Course Code: UMATC40204	Title of the Course: Introduction to Artificial Intelligence and Machine Learning
L-T-P: 3-0-0	Credits: 3
Semester: IV	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Learn the fundamentals of artificial intelligence and machine learning.

CLO-2: Know different types of AI and ML algorithms.

CLO-3: Understand supervised, unsupervised and reinforcement learning.

CLO-4: Learn computer vision of AI that trains computers to capture and interpret information from image and video data.

CLO-5: Apply AI and ML to real-world problems.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	2	2	3	1	3	1	1	1
CLO2	3	3	2	1	2	1	3	1	1	1
CLO3	3	3	2	1	3	2	3	1	1	1
CLO4	3	3	2	1	3	2	3	1	1	1
CLO5	3	3	2	1	3	3	3	1	1	3

Course Details:

Unit-I: Introduction to Artificial Intelligence (AI), Future of Artificial Intelligence, Characteristics of Intelligent Agents, Typical Intelligent Agents.

Unit-II: Introduction to machine learning (ML), probability for ML and linear regression, classification of machine learning problems, types of AI and ML algorithms, supervised, unsupervised and reinforcement learning etc.

Unit-III: Neural networks, introduction to cost functions, activation functions and optimization strategies. Types of neural networks: CNN, GNN theory and libraries, basics of decision trees.

Unit-IV: Introduction to Scikit, TensorFlow and PyTorch libraries, writing machine learning piplines, natural language processing and computer vision.

Course References:

1. Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2nd edition
2. Andrew Ng, Machine Learning, 2018.
3. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, 2016.
4. Andriy Burkov, The Hundred-Page Machine Learning Book, 2019.
5. Peter Flach, Machine Learning: The art and Science of Algorithms that make sense of Data, 2012.
6. Bart Kosko, Neural Networks and Fuzzy Systems, 1994.
7. Christopher M. Bishop, Pattern Recognition and Machine Learning, 2016.
8. Ellis Horowitz and Sartaj Shani, Fundamentals of Data Structures, 1982.
9. Kenneth H. Rosen, Discrete Mathematics and its Applications, 2017.
10. Martin C. Brown, Python the Complete Reference, 2018.
11. S. Russell, P. Norvig, Artificial Intelligence: A Modern Approach, 2010.
12. Simon Haykin, Neural Networks, 2005.
13. B. YagnaNarayana , Artificial Neural Networks, PHI, 2012.
14. N. P. Padhy – Artificial Intelligence and Intelligence Systems, OXFORD publication, 2005.

Course Code: UMATC40205	Title of the Course: Real Analysis
L-T-P: 3-1-0	Credits: 4
Semester: IV	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Describe the real line as a complete, ordered field.

CLO-2: Identify challenging problems in real variable theory and find their appropriate solutions.

CLO-3: Deal with axiomatic structure of metric spaces and generalize the concepts of sequences and series, and continuous functions in metric spaces.

CLO-4: Test whether a given improper integral can be convergent.

CLO-5: Use theory of multiplications of series and infinite products in solving problems arising in different fields of science and engineering.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO-1	1		2			1				
CLO-2		3			2		3			
CLO-3				2			3			
CLO-4			2				2			
CLO-5		3		1		2				

Detailed Syllabus:

Unit-I: Elementary set theory, finite, infinite, bounded, unbounded, countable and uncountable sets, Cantor set. Real number system as a complete ordered field, Archimedean property, Dedekind cuts, supremum, infimum. Continuity, differentiability, functions of bounded variation, absolutely continuous, uniform continuous of a function of a single variable.

Unit-II: Sequences and series, power series, radius of convergence, product of series, re-arrangements, arbitrary series, absolute and conditional convergence.

Unit-III: Riemann integration, classification of Riemann integration, classification of improper integrals, tests for convergence of Beta and Gamma functions, differentiation of integral with variable limits.

Unit-IV: Metric space, limit, continuity, connectedness, compactness.

Course References:

1. Walter Rudin (1976), Principles of Mathematical Analysis, McGraw Hill Book Co.

2 T. M. Apostol (1987), Mathematical Analysis, Narosa Publications.

3. Richard R. Goldberg (1976), Methods of Real Analysis, second edition, John Wiley & Sons.

4. Robert G. Bartle (1976), The Elements of Real Analysis, second edition, John Wiley & Sons.

5. Kenneth A. Ross (2013), Elementary Analysis: The Theory of Calculus, second edition, Springer, New York.

6. Torence Tao (2006), Analysis I, Hindustan Book Agency, India.

7. Torence Tao (2006), Analysis II, Hindustan Book Agency, India.
8. S.C. Malik (1984), Mathematical Analysis, Wiley – Eastern.

Course Code: UMATC40206	Title of the Course: Computational Statistics
L-T-P: 3-1-0	Credits: 4
Semester: IV	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Understand the idea and usage of probability functions for discrete and continuous random variables to formulate a solution tool for probabilistic problems in different scientific domains.

CLO-2: Know Monte Carlo methods in statistics

CLO-3: Apply the different methods of sampling for discrete and continuous cases to do computations for different science, engineering, and real life problems.

CLO-4: Apply Maximum likelihood estimator for estimating a population parameter

CLO-5: Find a curve of best fit for a given data, and linear regression and to analyze the data samples

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	2	2	3	1	3	1	-	1
CLO2	3	3	2	1	2	1	3	1	-	1
CLO3	3	3	2	1	3	2	3	1	-	1
CLO4	3	3	2	1	3	2	3	1	-	1
CLO5	3	3	2	1	3	3	3	1	-	3

Course Details:

Prerequisites: Random variable and sample space - notion of probability - axioms of probability - empirical approach to probability - conditional probability - independent events - Bayes' Theorem.

Unit-I: Probability distributions with discrete and continuous random variables - Mathematical expectation - moment generating function - joint probability mass function, marginal distribution function, joint density function. Chebyshev's inequality - weak law of large numbers - Bernoulli trials - the Binomial, Exponential, Poisson, normal distributions and multivariate distributions.

Unit-II: Introduction to Monte Carlo methods, Pseudo random Number Generation, Sampling Discrete Random Variables: Inverse Transform Method, Discrete: Accept-Reject Algorithm, Composition Method, Sampling Continuous Random Variables: Inverse Transform Method. Continuous: Accept-reject Algorithm with examples, Box-Muller method. Continuous: Ratio-of-Uniforms method, examples and code, miscellaneous methods in sampling, Sampling from multivariate distributions.

Unit-III: Introduction to testing of hypothesis tests of significance for large and small samples, chi-square test for goodness of fit, t and F tests, theory of estimation, Simple Importance Sampling: Examples, bias, variance, consistency, optimal proposals. Weighted importance sampling: Examples, Maximum likelihood function, MLE examples.

Unit-IV: Linear and polynomial fitting by the method of least squares - linear correlation and linear regression, analysis of variance, linear regression as MLE, penalized regression, No-closed form MLEs, Review of Taylor series Approximations.

Course References:

1. S. C. Gupta and V. K. Kapur , "Fundamentals of Mathematical Statistics", (2008), S. Chand & Sons.
2. V. K. Rohatgi and A.K. Md. Ehsanes Saleh , "An Introduction to Probability theory and Mathematical Sciences", (2001), Wiley.
3. Sheldon Ross, "Simulation" , Elsevier, Fifth Edition.
4. Christian Robert and George Casella, "Monte Carlo Statistical Methods"(2004), Springer.
5. Sheldon Ross, "A First Course in Probability", sixth edition , Pearson Education.
6. Miller and Freund's, Probability and Statistics for Engineers, 8th edition, 2011.

Course Code: UMATC40207	Title of the Course: Partial Differential Equations
L-T-P: 3-1-0	Credits: 4
Semester: IV	Type of the Course: Theory

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Analyze the origin of first-order partial differential equations, classification and geometrical interpretation of PDEs.

CLO-2: Classify the second-order differential equations and ability to solve the homogeneous & non-homogeneous linear partial differential equations.

CLO-3: Solve the wave equation by separating variables and integral transforms.

CLO-4: Solution of Laplace equation in Cartesian and polar coordinates in Rectangular and circular regions

CLO-5: Apply the knowledge of PDE to resolve real-world problems.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	3							
CLO2	3	3	2	2						
CLO3			3	2				2		
CLO4				3	2	2				
CLO5							2			2

Course Details:

Unit-I: Introduction to PDE, Basic definitions, Origin of PDEs, Classification of PDEs, Geometrical interpretation, Linear, quasi-linear, nonlinear Equations-Method of characteristics, Lagrange method.

Unit-II: Introduction to second-order PDE, Definitions of Linear and Nonlinear equations, solutions of linear Homogeneous and non-homogeneous with constant coefficients, Variable coefficients,

Classification of second-order linear partial differential equations, Canonical forms of equations in two independent variables.

Unit-III: Wave equation: Solution by the method of separation of variables and integral transforms, wave equation in cylindrical and spherical polar coordinates. **Laplace equation:** Solution by separating variables and integral transforms, Solution by Cartesian and polar Coordinates-Rectangular regions, circular regions.

Unit-IV: Diffusion equation: Solution by the method of separation of variables and integral transforms, Maximum Minimum principle for the diffusion equation.

Course References:

1. I. N. Sneddon (2006), Elements of partial differential equations, McGraw-Hill, New York.
2. L Debnath (2007), Nonlinear PDE's for Scientists and Engineers, Birkhauser, Boston.
3. F. John (1971), Partial differential equations, Springer.
4. Jeffery Cooper (1998), Introduction to partial differential equations with matlab, Birkhauser,
5. Clive R Chester (1971), Techniques in partial differential equations, McGraw-Hill.
6. W. E. Williams (1980), Partial differential equations, Clarendon Press, Oxford.
7. Tyn Myint-U and Lokenath Debnath (2007), Linear Partial Differential Equations for Scientists and Engineers, Fourth Edition, Birkhauser.
8. R.P. Agarwal and D. O'Regan (2009), Ordinary and Partial Differential Equations, Springer- Verlag.
9. Ioannis P Stavroulakis and Stepan A Tersian (1999), Partial differential equations- an introduction with mathematica and maple, world - Scientific, Singapore.
10. F. Treves (1975), Basic linear partial differential equations, Academic Press.
11. M.G. Smith(1967), Introduction to the theory of partial differential equations, Van Nostrand.

Course Code: UMAWC40200	**Title of the Course: Programming Workshop (Data Analytics using R Programming and GPU computing)**
L-T-P: 1-0-2	**Credits: 2**
Semester: IV	**Type of the Course: Theory cum Practical**

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Understand the fundamentals of R, loading and retrieval techniques of data. Also, analyse, interpret correlation and regression, the underlying relationships between different variables.

CLO-2: Learn mathematical and statistical computations, programming and simulations.

CLO-3: Apply terminology commonly used in parallel computing, such as efficiency and speedup. Also, describe common GPU architectures and programming models.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO-1	2	3	3	1	3	1	3	3		
CLO-2	3	3	3	2	2	2	2			
CLO-3	1	3	2	3	3	2	1			

Detailed Syllabus:

Unit-I (Introduction to R, R-Data Types and R-Function): Basic fundamentals, advantages of R over other Programming Languages, R Studio: R command Prompt, R script file, comments, installing a R Package and use of R-software, data editing, use of R as a calculator, functions and assignments, functions and matrix operations, missing data and logical operators, conditional executions and loops, data management with sequences, data management with repeats, sorting, ordering, and lists. Vector indexing, factors, Data management with strings, display and formatting.

Unit-II (Data Frames, Loading and Handling Data in R, Statistics and Data Analysis): Data management with display paste, split, find and replacement, manipulations with alphabets, evaluation of strings, data frames, import of external data in various file formats, statistical functions, compilation of data, graphics and plots, statistical functions for central tendency, variation, skewness and kurtosis, handling of bivariate data through graphics, correlations, programming and illustration with examples.

Unit-III (Introduction to GPU Computing and Memory): History, GPU Architecture, Clock speeds, CPU / GPU comparisons, Heterogeneity, Accelerators, Parallel Programming, CUDA OpenCL / OpenACC, Kernels Launch parameters, Thread hierarchy, Warps/Wavefronts, Threadblocks/Workgroups, Streaming multiprocessors, 1D/2D/3D thread mapping, Device properties, Simple Programs. **Memory:** Memory hierarchy, DRAM / global, local / shared, private / local, textures, Constant Memory, Pointers, Parameter Passing, Arrays and dynamic Memory, Multi-dimensional Arrays, Memory Allocation, Memory copying across devices, Programs with matrices, Performance evaluation with different memories.

Course References:

1. Introduction to Statistics and Data Analysis - With Exercises, Solutions and Applications in R By Christian Heumann, Michael Schomaker and Shalabh, Springer, 2016
2. The R Software-Fundamentals of Programming and Statistical Analysis -Pierre Lafaye de Micheaux, Rémy Drouilhet, Benoit Liquet, Springer 2013
3. A Beginner's Guide to R (Use R) By Alain F. Zuur, Elena N. Ieno, Erik H.W.G. Meesters, Springer 2009
4. Sandip Rakshit, R Programming for Beginners, McGraw Hill Education (India), 2017, ISBN : 978-93-5260-455-5.
5. Seema Acharya, Data Analytics using R, McGrawHill Education (India), 2018, ISBN: 978-93-5260-524-8.
6. Tutorials Point (I) simply easy learning, Online Tutorial Library (2018), R Programming, Retrieved from https://www.tutorialspoint.com/r/r_tutorial.pdf. (Online Resource)
7. Andrie de Vries, Joris Meys, R for Dummies, A Wiley Brand, 2nd Edition, John Wiley and Sons, Inc, 2015, ISBN: 978-1-119-05580-8.
8. David Kirk and Wen-mei Hwu, Programming Massively Parallel Processors: A Hands-On Approach, 2nd Edition, Publisher: Morgan Kaufman, 2012, ISBN: 9780124159921.
9. Shane Cook, CUDA Programming: A Developer's Guide to Parallel Computing with GPUs, Morgan Kaufman; 2012 (ISBN: 978-0124159334)

Course Code: UMAPC40201	**Title of the Course: Lab on Artificial Intelligence and Machine Learning**
L-T-P: 0-0-2	**Credits: 1**
Semester: IV	**Type of the Course: Practical**

Course Learning Outcomes (CLOs)

After studying this course the student will be able to

CLO-1: Learn Python programming in artificial intelligence and machine learning.

CLO-2: Gain hands-on experience with AI and ML algorithms.

CLO-3: Apply AI and ML to real-world problems.

Mapping of Course Learning Outcomes (CLOs) with Program Learning Outcomes (PLOs)

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6	PLO 7	PLO 8	PLO 9	PLO 10
CLO1	3	3	2	2	3	1	3	1	1	1
CLO2	3	3	2	1	2	1	3	1	1	1
CLO3	3	3	2	1	3	2	3	1	1	1

Course Details:

Unit-I: Introduction to Python Programming in artificial intelligence and machine learning. Working with data analysis using Python to implement and evaluate artificial intelligence and machine learning algorithms.

Unit-II: Practice the programs on linear regression using Python, Neurons, neural networks and multilayer perceptrons in Python, Binary classification problem, Multiclass classification problem, Regression problem, Graph Neural Network problem. Programs on applying artificial intelligence and machine learning algorithms to real-world problems.

Course References:

1. Wes McKinney, Python for Data Analysis, 2nd edition 2018.
2. Al Sweigart, Automate the Boring Stuff with Python, 2015.
3. Zed A. Shaw, Learn Python3: The Hard Way, 2017.
4. Andrew Ng, Machine Learning, 2018.
5. Ian Goodfellow, Yoshua Bengio, and Aaron Courville, Deep Learning, 2016.
6. Andriy Burkov, The Hundred-Page Machine Learning Book, 2019.

Syllabus of V-VIII Semesters

(To be Updated)