SRI SATHYA SAI INSTITUTE OF HIGHER LEARNING

(Deemed to be University)

Syllabus for
B.Sc.(Hons) in Mathematics
Batch 2019 -2020 onwards

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DEPARTMENT OF MATHEMATICS & COMPUTER SCIENCE

Syllabus for Three Year B.Sc. (Hons.) in Mathematics

(Effective from the Academic Year 2019-2020 batch onwards)

Programme Objectives:

›› In the first two years of study, all three subjects (Mathematics, Computer Science and Statistics) are taught
›› In the third year, only Mathematics course will be taught, leading to the final degree awarded: B.Sc. (Hons.) in Mathematics.

The programme is built on the four paradigms to study science: Theory, Experiment, Data Analysis and Simulation. In the first two formative years, the focus is given on Computer Science training in the current, modern context. This includes: The use of a computer more as a tool for problem solving, Data Structures with Python, Database or Information system (including associated lab work), Data Visualization, Artificial Intelligence (AI) and Web Technology and Design.

B.Sc. Honours is a six-semester program. Students are admitted to this program after completing 12th class under CBSE (or equivalent) boards from any state of India. In the first four semesters students take a three subject combination (say Mathematics, Physics and Chemistry or Mathematics, Economics and Statistics, etc.). In the last two semesters they specialize in one of the three subjects for Honors degree. Students after completing the program either join M.Sc. Mathematics or some professional courses like MCA or take up jobs in various fields including software development.

Programme Specific Objectives:

The B.Sc. Mathematics Honors syllabus aims to achieve the following objectives:

1. **To provide a broad based knowledge of mathematics:** For this purpose courses have been built based on students' knowledge at the entry level. For example Calculus of several variables based on Calculus of one variable, Linear algebra based on Matrix theory, etc.

2. **To provide the essential mathematical tools:** For this purpose, a number of courses such as Differential Equations, Probability Theory, Linear Programming

etc. are given which train the students in using the mathematics as tools in all the branches of science as well as social sciences.

3. **To develop mathematical understanding:** This is achieved by courses like Foundations of Mathematics, Real analysis, Abstract Algebra, Linear Algebra with emphasis on writing and designing proofs. These courses give the students the much-needed foundation in rigour of mathematical thinking.

4. **To strengthen mathematical base:** In the last two semesters, of the Honours program the students are to undergo additional courses on Abstract Algebra, Linear Algebra. Also they are exposed to sophistications of Complex analysis, Topology, Numerical Methods. This is to satisfy the need to strengthen the basics of the students who opt for mathematics Honours. These courses form the core of the Honours programme.

5. **To develop interest in specialization:** In each of the last two semesters elective courses are provided. Students can choose the electives from two streams – namely Mathematics and Computer Science, depending on their interest.

6. **To train in computer usage:** This is achieved by the provision of Software laboratory courses, one in each of the last two semesters. Here the students learn some programming languages as well as hands on experience on computer usage on different platforms.

7. **To train students in Research**: In order to train the students in research a provision has been made for a project in the Third Year of the programme. This is a 3 Credit project. Student may opt for it in lieu of one of the four elective courses in the B.Sc Math Hons. programme.

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Undergraduate HonoursProgramme Structure consists of Three Parts.

PART-I: LANGUAGES#
(a) General English (four papers offered, one each in the first four semesters)
(b) Another Language (four papers offered, one each in the first four semesters – Any one out of: HINDI / SANSKRIT / TELUGU / ADDITIONAL ENGLISH)

PART-II: CORE SUBJECTS
(Offered in all the six semesters) – Title of the papers are given below in the Scheme of Instruction & Evaluation and the syllabus contents are enclosed.

Part-II consists of three-subject-combination during the first four semesters, which, each student has to study. Three Subject combinations that are offered in the Honours Programme are Mathematics/Physics/ Chemistry; and Mathematics/Economics/Statistics). During the fifth and sixth semesters the students will choose one of the three subjects in the three-subject-combination as subject of exclusive study for Honours. (i.e., either MATHEMATICS or PHYSICS or CHEMISTRY or ECONOMICS).

PART-III: AWARENESS COURSES and ENVIRONMENTAL COURSES##
a) Awareness Courses – (six papers offered, one each in all the six semesters)
b) Environmental Courses – (two papers offered, one each in the first two semesters)

NOTE: The title of the papers and the syllabus contents of Part-I and Part-III are provided separately.

SCHEME OF INSTRUCTION AND EVALUATION

(Effective 2019/20 batch onwards)

ABSTRACT

for B.Sc.(Hons.) in Mathematics with MPC combination

	Credits	Hours	Maximum Marks
PART-I: LANGUAGES			
PART-I TOTAL	**36** credits	**36** hours	**800** marks
PART-II: CORE SUBJECTS			
PART-II TOTAL (Honours in Mathematics)	**66** credits	**72** hours	**1950** marks

PART-II TOTAL (Physics)	**18** credits	**29** hours	**600** marks
PART-II TOTAL (Chemistry)	**18** credits	**26** hours	**600** marks

PART-III: AWARENESS and ENVIRONMENTAL COURSES			
PART-III TOTAL	**16** credits	**16** hours	**450** marks

GRAND TOTAL (B.Sc.(Hons.) in Mathematics)	**154** credits	**176** hours	**4400** marks

ABSTRACT

for B.Sc.(Hons.) in Mathematics with MES combination

	Credits	Hours	Maximum Marks
PART-I: LANGUAGES			
PART-I TOTAL	**36** credits	**36** hours	**800** marks
PART-II: CORE SUBJECTS			
PART-II TOTAL (Honours in Mathematics)	**66** credits	**72** hours	**1950** marks
PART-II TOTAL (Economics)	**20** credits	**20** hours	**400** marks
PART-II TOTAL (Statistics)	**18** credits	**18** hours	**400** marks
PART-III: AWARENESS and ENVIRONMENTAL COURSES			
PART-III TOTAL	**16** credits	**16** hours	**450** marks
GRAND TOTAL (B.Sc.(Hons.) in Mathematics)	**156** credits	**162** hours	**4000** marks

ABSTRACT

for B.Sc.(Hons.) in Mathematics with M-CS-S combination

	Credits	Hours	Maximum Marks
PART-I: LANGUAGES			
PART-I TOTAL	**36** credits	**36** hours	**800** marks
PART-II: CORE SUBJECTS			
PART-II TOTAL (Honours in Mathematics)	**66** credits	**72** hours	**1950** marks
PART-II TOTAL (Computer Science)	**20** credits	**36** hours	**600** marks

PART-II TOTAL (Statistics)	**18** credits	**18** hours	**400** marks
PART-III: AWARENESS and ENVIRONMENTAL COURSES			
PART-III TOTAL	**16** credits	**16** hours	**450** marks
GRAND TOTAL (B.Sc.(Hons.) in Mathematics)	**156** credits	**162** hours	**4200** marks

PART-I: LANGUAGES

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UGEN-101	General English-I #	**5**	5	IE1	T	100
	Another Language-I #	**4**	4	IE1	T	100
Semester II						
UGEN-201	General English-II #	**5**	5	IE1	T	100
	Another Language-II #	**4**	4	IE1	T	100
Semester III						
UGEN-301	General English-III #	**5**	5	IE1	T	100
	Another Language-III #	**4**	4	IE1	T	100
Semester IV						
UGEN-401	General English-IV #	**5**	5	IE1	T	100
	Another Language-IV #	**4**	4	IE1	T	100
	PART-I TOTAL	**36** credits	**36** hours			**800** marks

PART-II: CORE SUBJECTS (Honours in Mathematics)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UMAT-101	Multivariable Calculus	**4**	4	IE1	T	100
UMAT-102	Foundations of Mathematics	**2**	2	IE1	T	50
		6 credits	**6** hours			**150** marks
Semester II						
UMAT-201A **OR**	Probability * (MPC group) **OR**	**3**	3	IE1	T	100
UMAT-201B	Linear Programming ** (MES and MCS group)	**3**	3	IE1	T	100
UMAT-202	Methods of Ordinary Differential Equations	**3**	3	IE1	T	100
		6 credits	**6** hours			**200** marks

Semester III						
UMAT-301	Introduction to Real Analysis	**3**	3	IE1	T	100
UMAT-302	Introduction to Linear Algebra	**3**	3	IE1	T	100
		6 credits	**6** hours			**200** marks

Semester IV						
UMAT-401	Real Analysis	**3**	3	IE1	T	100
UMAT-402	Algebraic Structures-I	**3**	3	IE1	T	100
		6 credits	**6** hours			**200** marks

Semester V						
UMAT-501	Complex Analysis	**4**	4	IE1	T	100
UMAT-502	Topics in Linear Algebra	**4**	4	IE1	T	100
UMAT-503	Topology	**4**	4	IE1	T	100
UMAT-504	Elective-I #	**3**	3	IE1	T	100
UMAT-505	Elective-II#	**3**	3	IE1	T	100
UMAT-506	Software Lab-I Introduction to C programming	**3**	6	I	P	100
		21 credits	**24** hours			**600** marks

Semester VI						
UMAT-601	Algebraic Structures-II	**4**	4	IE1	T	100
UMAT-602	Numerical Methods	**4**	4	IE1	T	100
UMAT-603	Methods of Differential Equations	**4**	4	IE1	T	100
UMAT-604	Elective-III #	**3**	3	IE1	T	100
UMAT-605	Elective-IV#	**3**	3	IE1	T	100
UMAT-606	Software Lab II Data Structures and file handling in C	**3**	6	I	P	100
		21 credits	**24** hours			**600** marks

	PART-II TOTAL- (Honours in Mathematics)	**66** credits	**72** hours			**1950** marks

Notes: 1. The Choice of Electives and Streams of Specialization offered shall be decided by the Head of the Department.

***** UMAT- 201 A is applicable for MPC group students only and

****** UMAT- 201 B is applicable for MES and MCS group students only as a CORE paper. For MPC group students Linear Programming is available as an elective UAM-7 in 5th and 6th semesters.

Student may opt for doing a project in lieu of any one of the four Electives offered in the Third year. The project is for 3 Credits and evaluated for 100 Marks. Evaluation of the project is Internal by the project committee appointed by the HoD. The Evaluation method is given below:

1. Evaluation will be done in THREE parts.

2. First Evaluation is within the first FIVE weeks of the semester for 20% of total Marks. The student is to submit a short written report and face an oral examination by the project committee.
3. Second Evaluation component is spread across the semester. The project supervisor will evaluate the progress of the candidate in the project work on a weekly basis. This component is for 30% of total Marks.
4. Third Evaluation is at the end of the semester for 50% of total Marks. The student is to submit a project report and make an oral presentation. Following which there will be an oral examination by the project committee.
5. **Project Committee:** A student doing project must have a *project supervisor* allotted by the HoD. Project supervisor and another member of the Department nominated by the HoD constitute the Project Committee.

PART-II CORE SUBJECTS: (Physics)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UPHY-101	Electronics-I: Analog & Digital	**3**	3	IE1	T	100
UPHY-102	Electronics Laboratory-I	**1**	3	I	P	50
		4 credits	**6** hours			**150** marks
Semester II						
UPHY-201	Optics	**3**	3	IE1	T	100
UPHY-202	Optics Laboratory	**1**	3	I	P	50
		4 credits	**6** hours			**150** marks
Semester III						
UPHY-301	Classical Mechanics	**4**	4	IE1	T	100
UPHY-302	Mechanics Laboratory	**1**	3	I	P	50
		5 credits	**7** hours			**150** marks
Semester IV						
UPHY-401	Electromagnetism	**4**	4	IE1	T	100
UPHY-402	Electromagnetism Laboratory	**1**	3	I	P	50
		5 credits	**7** hours			**150** marks
	PART-II TOTAL (Physics)	**18** credits	**26** hours			**600** marks

PART-II CORE SUBJECTS: (Chemistry)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UCHM-101	Principles of Structure and Bonding	**3**	3	IE1	T	100

UCHM-102	Laboratory course in General Chemistry	**1**	3	I	P	50
		4 credits	**6** hours			**150** marks

Semester II						
UCHM-201	Chemical Thermodynamics	**3**	3	IE1	T	100
UCHM-202	Laboratory Course in Titrimetry and Thermodynamics	**1**	3	I	P	50
		4 credits	**6** hours			**150** marks

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester III						
UCHM-301	Chemical Kinetics and Equilibria	**4**	4	IE1	T	100
UCHM-302	Laboratory course on Chemical Kinetics and Equilibria	**1**	3	I	P	50
		5 credits	**7** hours			**150** marks
Semester IV						
UCHM-401	Chemistry of Organic Functional Groups	**4**	4	IE1	T	100
UCHM-402	Laboratory Course on Methods and Synthesis in Organic Chemistry	**1**	3	I	P	50
		5 credits	**7** hours			**150** marks
	PART-II TOTAL (Chemistry)	**18** credits	**26** hours			**600** marks

PART-II: CORE SUBJECTS (Economics)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UMEC-101	Economic Analysis - I	**5**	5	IE1	T	100
Semester II						
UMEC-201	Economic Analysis - II	**5**	5	IE1	T	100
Semester III						
UMEC-301	Introduction to Mathematical Economics	**5**	5	IE1	T	100
Semester IV						
UMEC-401	Development Economics	**5**	5	IE1	T	100
	PART-II TOTAL (Economics)	**20** credits	**20** hours			**400** marks

PART-II: CORE SUBJECTS (Computer Science)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
UCSC-101	Introduction to Information Systems	**3**	3	IE1	T	100
UCSC-102	Practicals: Introduction to Information Systems	**2**	6	I	P	50
Semester II						
UCSC-201	Problem Solving using Computers	**3**	3	IE1	T	100
UCSC-202	Practicals: Python Lab	**2**	6	I	P	50
Semester III						
UCSC-301	Data Visualization	**3**	3	IE1	T	100
UCSC-302	Practicals: Data Visualization Lab	**2**	6	I	P	50
Semester IV						
UCSC-401	Artificial Intelligence	**3**	3	IE1	T	100
UCSC-402	Practicals: Fundamentals of Linux/Unix Systems Lab	**2**	6	I	P	50
	PART-II TOTAL (Computer Science)	**20** credits	**36** hours			**600** marks

Note: Computer Science syllabus is given this booklet of B.Sc.(Hons.) Mathematics syllabus.

PART-II: CORE SUBJECTS (Statistics)

Paper Code	Title of the Paper	Credits	Hours	Modes of Evaluation	Types of Papers	Maximum Marks
Semester I						
USTA-101	Introductory Statistics	**4**	4	IE1	T	100
Semester II						
USTA-201	Probability Theory and Distributions	**5**	5	IE1	T	100
Semester III						
USTA-301	Statistical Inference	**5**	5	IE1	T	100
Semester IV						
USTA-401	Applied Statistics	**4**	4	IE1	T	100
	PART-II TOTAL (Statistics)	**18** credits	**18** hours			**400** marks

Note: Economics syllabus is given the B.Sc.(MES) Hons. syllabus book.

PART-III: AWARENESS COURSES and ENVIRONMENTAL COURSES

Paper Code	Title of the Paper	Credits	Hours	Mode of Evaluation	Theory / Practicals	Maximum Marks
	Semester I					
UAWR-100	Awareness Course-I: Sai Education for Transformation (Based on Life and Teachings of Bhagawan Baba)	2	2	I	T	50
UENT-101	Environment-I	2	2	I	T	75
	Semester II					
UAWR-200	Awareness Course-II: Unity of Religions	2	2	I	T	50
UENT-201	Environment-II	2	2	I	T	75
	Semester III					
UAWR-300	Awareness Course-III: Study of Classics – I: Ramakatha Rasa Vahini	2	2	I	T	50
	Semester IV					
UAWR-400	Awareness Course-IV: Study of Classics – II: BhagawathVahini	2	2	I	T	50
	Semester V					
UAWR-500	Awareness Course-V: Eternal Values for the changing World	2	2	I	T	50
	Semester VI					
UAWR-600	Awareness Course-VI: Life and its Quest	2	2	I	T	50
	Semester VII					
UAWR-700	Awareness Course-VII: Music and Spirituality-1	2	2	I	T	50
	Semester VIII					
UAWR-800	Awareness Course-VIII: Music and Spirituality-2	2	2	I	T	50
	PART-III TOTAL	**20** credits	**20** hours			**550** marks

Modes of Evaluation
Types of Papers

Indicator	Legend
IE1	CIE and ESE ; ESE single evaluation
IE2	CIE and ESE ; ESE double evaluation
I	Continuous Internal Evaluation **(CIE)** only Note: 'I' does not connote 'Internal Examiner'
E	End Semester Examination **(ESE)** only Note: 'E' does not connote 'External Examiner'
E1	ESE single evaluation
E2	ESE double evaluation

Indicator	Legend
T	Theory
P	Practical
V	Viva voce
PW	Project Work
D	Dissertation

Continuous Internal Evaluation (CIE) & End Semester Examination (ESE)

PS: Please refer to guidelines for 'Modes of Evaluation for various types of papers', and 'Viva voce nomenclature & scope and constitution of the Viva-voce Boards'.

List of Core Courses

UMAT-101	Multivariable Calculus
UMAT-102	Foundations of Mathematics
UMAT-201A	Probability (for MPC group only)
UMAT-201B	Linear Programming (for MES group only)
UMAT-202	Methods of Ordinary Differential Equations
UMAT-301	Introduction to Real Analysis
UMAT-302	Introduction to Linear Algebra
UMAT-401	Real Analysis
UMAT-402	Algebraic Structures - I
UMAT-501	Complex Analysis
UMAT-502	Topics in Linear Algebra
UMAT-503	Topology
UMAT-601	Algebraic Structures II
UMAT-602	Numerical Methods
UMAT-603	Methods of Differential Equations

List of Elective Courses

Stream I (Mathematics)

UM-1	Geometry
UM-2	Combinatorics
UM-3	Elementary Number theory
UM-4	Graph Theory
UM-5	Continuum Mechanics
UM-6	Operations Research
UM-7	Linear Programming
UM-8	Introduction to Coding Theory
UM-9	Discrete Mathematics

Stream II (Computer science)

UCS-1	Introduction to Computer Science
UCS-2	Fundamentals of Computer Systems
UCS-3	Data Structures and Algorithms
UCS-4	Mathematical Logic for Computer Science
UCS-5	Design of Algorithms

CODE : UMAT-101 Multivariable Calculus Credits 4

Course Objectives: This course will introduce students to functions of two and three variables. It familiarizes students about the limit, continuity and differentiability in functions of two and three variables. Double and triple integrals are introduced and their application are introduced.

Course Outcomes

I) Understanding of Functions of two and three variables.

II) Understanding of Limit, continuity and differentiability of Functions of two and three variables. Partial derivatives and their geometric significance.

III) Understanding how to evaluate double and triple integrals and their use for finding areas and volumes

IV) Understanding of Vector valued functions and their use for finding tangents, normal, and arc length of space curves.

(V) Understanding the applications of Green's, Stokes' and Divergence Theorem.

Content:

S.no	TOPIC	
1	**Preliminaries** Polar Coordinates Cylinders and quadric surfaces Functions of one variable (1 period)	**4 periods**
2	**Vector-valued functions and motion in space** Curves in space and their tangents Arc lengths in space Curvature and Normal vectors of a curve	**8 periods**
3	**Partial Derivatives** Preliminaries on limit, continuity and derivatives for functions of one variable (2 periods) Functions of Several Variables Limits and Continuity in Higher Dimensions Partial Derivatives The Chain Rule Directional Derivatives and Gradient Vectors Tangent Planes and Differentials Extreme Values and Saddle Points Lagrange Multipliers	**20 periods**
4	**Multiple Integrals** Preliminaries on integration for functions of one variable (1 period) Double and Iterated Integrals over Rectangles Double Integrals over General Regions	**13 periods**

Area by Double Integration
Double Integrals in Polar Form
Triple Integrals in Rectangular Coordinates
Cylindrical and Spherical Co-ordinates

5	**Integration in Vector Fields** Vector Fields and Line Integrals: Work, Circulation, and Flux Green's Theorem in the Plane Surface Integrals and Stokes theorem Divergence Theorem	**11 periods**
Total		**56 periods**

Key Text(s)	Thomas' Calculus. George B. Thomas Jr, Addison-Wesley, 12th Edn.
Coverage of Key Text(s)	Chapters 11: 11.3, 12: 12.6, 13: 13.1, 13.3, 13.4, 14: 14.1-14.8, 15: 15.1-15.5, 15.7, 16: 16.2, 16.4, 16.6-16.8

* **Proofs of Green's theorem, Stokes theorem and Divergence theorem are omitted. Problems related to Divergence Theorem which involve cylindrical and spherical are to be omitted.**
*** From section 15.7 only introduction to Cylindrical and Spherical Co-ordinates is to be covered.**

References:	Multivariable Calculus with Vectors Hartley Rogers Jr., copyright 1998. Prentice Hall,

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CODE : UMAT-102 Foundations of Mathematics Credits 2

Course Objectives: Introduces students to language of Mathematics. Students are introduced to problems whose solution involves mathematical reasoning using different proof techniques. It familiarizes students to equivalence relations and real functions

Course Outcomes:

(i) Understanding the language of Mathematics through symbol, common words.

(ii) Understanding of sets and Set operations

(iii) Understanding of how to construct proofs of the theorems that are mathematically correct and clearly written using, logic, Direct proof, proof by contradiction and contrapositive methods.

(iv) Understanding of Equivalence relations and Equivalence classes.

(v) It gives understanding of various types of functions such as one-to-one, onto and inverse function.

Content:

S.no	TOPIC	
1	**Communicating Mathematics** Learning Mathematics, Mathematical Writing, Using Symbols, Writing Mathematical Expressions, Common Words and Phrases in Mathematics	**3 periods**
2	**Sets** Describing a Set, Subsets, Set operations, Indexed Collections of Sets, Partitions of Sets, Cartesian Products of Sets	**4 Periods**
3	**Logic** Statements, Negation of a Statement, Disjunction and Conjunction of Statements, Implication, Biconditional, Tautologies, Contradictions, Logical Equivalence, Some fundamental properties of logical equivalence, quantified statements, characterizations of statements	**4 Periods**
4	**Direct Proofs and Proof by Contrapositive** Trivial and Vacuous proofs, Direct proofs, Proof by Contrapositive, Proof by Cases, Proof Evaluations	**4 Periods**
5	**Existential and Proof by Contradiction** Counterexamples, Proof by Contradiction, Review of Three proof techniques, Existence proofs, Disproving existence statements	**4 Periods**

6 Equivalence relations **4 Periods**

Relations, Properties of relations, Equivalence relations, Properties of equivalence classes, Congruence modulo n, The Integers modulo n

7 Functions **5 Periods**

The Definition of Functions, The Set of all functions from A to B, One-to-One and Onto functions, Bijective functions, Composition of functions, Inverse functions and Permutations

Total **28 Periods**

Key Text(s): Mathematical Proofs: A Transition to Advanced Mathematics
Gary Chartand, Albert D. Polimen. Ping Zhang, Pearson Publishers, 3rd Edn.

Coverage of Key Text(s) Chapters: 0 to 3, 5, 8 and 9.

References: The Foundations of Mathematics
Ian Stewart, David Tall, second edition, Oxford University Press.

Probability

CODE : UMAT-201A (MPC Group Only) **CREDITS 3**

Course Objectives: This course introduces students to probability and related concepts. It familiarizes students to probability distributions and probability densities and mathematical expectation.

Course Outcomes:

(i) Understanding the term probability and concepts related to probability. It gives an understanding of conditional probability, Bayes Theorem and its applications

(ii) Understanding Probability distribution, Probability densities and Mathematical Expectation. It gives an understanding of how to calculate Mathematical Expectation of an event and quantities associated to Multivariate Probability distribution and densities.

(iii) Understanding some common Discrete and Continuous Probability distributions and their parameters.

Content:

S. no	TOPIC	
1	**PREREQUISITE** : Permutation – Combination - Binomial Theorem - Binomial Coefficients (as in Ch 1)	**1Period**
2	**Probability** Definitions – Sample Space - Event – Probability of an Event – Rules on Probability – Conditional Probability – Independent Events – Bayes' Theorem	**9 Periods**
3	**Probability Distributions and Probability Densities** Random Variable – Probability Distributions – Continuous Random Variables – Probability Density Functions – Multivariate Distributions – Marginal Distributions – Conditional Distributions.	**10 Periods**
4	**Mathematical Expectation** Expected Value of a Random Variable - Moments - Chebyshev's Theorem - Moment-Generating Function	**7 Periods**
5	**Discrete Probability Distributions** Discrete Uniform Distribution – Bernoulli Distribution- Binomial Distribution – Poisson Distribution	**9 Periods**
6	**Continuous Probability Distributions** Continuous Uniform Distribution – Normal Distribution – Normal Approximation to Binomial Distribution	**6 Periods**
	Total	**42 Periods**

Key Text(s)	John Freund's Mathematical Statistics with Applications, by Irwin Miller & Marylees Miller, 8th Ed, Pearson (2004)
Coverage of Key Text	Chapters - 2 : 2.1 to 2.8; 3 : 3.1 to 3.7; 4 : 4.1 to 4.5; 5 : 5.1 to 5.4, 5.7; 6 : 6.1, 6.2, 6.5, 6.6
References:	**1.** A First Course in Probability Sheldon Ross, 6th Edition, Pearson Publications 2. Understanding Probability Henk Tijms, 3rd Edition, Cambridge University Press

LINEAR PROGRAMMING

CODE : UMAT- 201B (MES and MCS Group Only) **CREDITS 3**

Course Objectives:

Define and formulate linear programming problems. Solve linear programming problems using appropriate techniques and interpret the results obtained. Conduct and interpret post- optimal sensitivity analysis and explain the primal –dual relationship. Develop mathematical skills to analyze network models arising from a wide range of applications.

Course Outcomes:

On Successful completion of the course students will be able to:

- Explain what a linear optimization problem is and how it can be solved.
- Analyze solutions to linear optimization problem and interpret the results.
- Solve transportation models and assignment models used in business.

S.no	Topic	
1	**Graphical Method** Two-Variable LP Model - Graphical Solution	**4 Periods**
2	**Algebraic Methods** Simplex Method - Artificial Starting Solution : Big M-Method - Two-Phase Method - Special Cases in Simplex Method - Sensitivity analysis	**12 Periods**
3	**Duality** Dual Problem - Primal-Dual Relationships - Dual simplex method and Generalized simplex method - Post optimal analysis	**8 Periods**
4	**Transportation Models** Transportation Algorithm - Assignment Model: Hungarian - Method - Transshipment Model Simplex Method Explanation of the Method of Multipliers Simplex Explanation of the Hungarian Method	**9 Periods**
5	**Network Models** Network definitions - Minimal Spanning Tree - Shortest-Route in a Network: Dijkstra's Algorithm - Floyd's Algorithm - Maximal Flow model Linear Programming Formulation of Shortest Route Problem Linear Programming Formulation of Maximal Flow	**9 Periods**
Total		**42 Periods**

Key Text(s) Operations Research - An Introduction
Hamdy A. Taha, 8th Ed, Pearson (2002)

Coverage of Key Text Chapters 1, 2 : 2.1 to 2.2, 3, 4 , 5 , 6 : 6.1 to 6.

References: Introduction to Operations Research

Frederick S. Hittier, Gerald J Liberman, Bodhibrata Nag, Preetam Basu

Tata Mc Graw Hill, New Delhi, 2017.

CODE: UMAT-202 Methods of Ordinary Differential Equations Credits 3

Course Objectives: It introduces students to First and Higher order differential equations, Boundary value problems and existence of their solution. It familiarizes students to various methods of solving them. It introduces students to how to model certain type of problems as differential equation.

Course Outcomes:

(i) Understanding of various types of differential equations.

(ii) Understanding the meaning of initial and boundary value problems and existence of their solutions.

(iii) Understanding standard methods for solving Ordinary Differential Equations of First and higher orders.

(iv) Understanding how an Ordinary Differential Equations model type of problems such as Bacterial growth, Newton's Law cooling etc.

Content:

S.no	TOPIC	
1	**Differential Equations and Their Solutions** Classification of Differential equations, their origin and applications Solutions, Initial Value Problem, Boundary Value Problem and Existence	**6 periods**
2	**Solutions for First Order Equations** Exact Differential Equations and integrating factors Separable Equations and equations reducible to this form Linear Equations and Bernoulli Equations Special Integrating Factors and transformations Modeling with first order equations Differences between linear and nonlinear equations	**18 periods**
3	**Exact Solutions for Higher Order Linear Equations** Basic theory of linear differential equations Homogeneous Equation with Constant Coefficients Method of Undetermined Coefficients Variation Of Parameters Cauchy-Euler Equation Theorems on the second order homogeneous Linear differential equations	**18 periods**
	Total	**42 periods**

Key Text(s) (i) Introduction to Ordinary Differential Equations
Shepley L. Ross, 4th Edition, Wiley

(ii) Elementary Differential Equations and Boundary Value Problems
William E. Boyce & Richard C. DiPrima, 10th edition, 2012, John Wiley & Sons

Coverage of Key Text(s) Book 1: Chapters: 1, 2 and 4
Book 2: Chapter 2: 2.3, 2.4

References: Ordinary Differential Equations
Morris Tenenbam, Harry polland, Dover publications, NY.

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CODE : UMAT-301 Introduction to Real Analysis Credits 3

Course Objective: It will introduce students to basic properties of Real Numbers from the point of topology. It will familiarizes students to sequences and series of real functions and their convergence criteria.

Course Outcomes:

(i) Understanding basic topological properties of real numbers

(ii) Understanding sequences and series of real numbers and their convergence.

(iii) Understanding concept of convergence in power series.

Content:

S.no	TOPIC	
1	Cardinality Equinumerous- denumerable set - countable set.	**4 Periods**
2	**Real Numbers** Natural number and Induction Ordered Field Completeness Axiom Basic Topology of the Reals and Compactness	**12 Periods**
3	**Sequences** Convergence Limit theorems Monotone Sequence and Cauchy Sequence Subsequence	**12 Periods**
4	**Series** Convergence of Infinite Series Convergence Tests Power Series	**14 Periods**
	Total	**42 Periods**

Key Text(s) Analysis – An Introduction to Proof
Steven R Lay – Prentice Hall 5th Edition

Coverage of Key Text(s) Chapters: 2.4.6 to 2.4.13, 3 (except section 3.6), 4, 8

References: Introduction to Real Analysis
Robert G Bartle, Donald R Sherbert, 4th edition, Wiley publications

CODE : UMAT- 302 **Introduction to Linear Algebra** **Credits 3**

Course Objectives: It introduces students to Vector Spaces and related concepts such as basis and dimension of it. It familiarizes students to Linear Transformations, system of linear equations, eigenvalues and eigenvectors

Course Outcomes:

(i) Understanding of Vector Spaces, Subspaces, Basis and dimension of finite dimensional vector spaces.

(ii) Understanding of Linear Transformations and their representation by Matrices. It gives understanding of image and kernel of a Linear Transformations and isomorphism.

(iii) Understanding of how to find solution of system of linear equations if it exists.

(iv) Understanding of Eigen values and Eigen Vectors of Endomorphisms.

Content:

S.no	TOPIC	
1	**Vector Spaces** Definition, Properties, Examples	**3 Periods**
2	**Subspaces** Definition, Properties, Examples	**4 periods**
3	**Linear Independence and Dependence** Definition, Properties, Examples	**4 periods**
4	**Bases and dimension** Finite dimensional vector spaces, Bases, Dimension, properties	**4 periods**
5	**Linear Transformations** Definition, properties, kernel and image, linear extension, isomorphism, singular transformation	**8 periods**
6	**Matrices and Linear Transformations** Introduction, Matrix of a linear transformation, Basic theorems, Matrices of nilpotent, projection and cyclic transformations	**8 periods**
7	**System of Linear Equations** Existence of solution, Affine subspace, Echelon matrix method	**4 periods**
8	**Eigen Values and Eigen Vectors** Rank of an Endomorphism – Eigen values and Eigen Vectors, The characteristic polynomial	**7 periods**
	Total	**42 periods**

Key Text(s)	Linear algebra Larry Smith, UTM Springer-Verlag, 3rd edition
Coverage of Key Text(s)	Chapters 2 (except 2.3), 3 to 9, 11,12,13 (only 13.1 and 13.2), 14 (14.1, 14.2 and 14.4)
References	**1.** Linear Algebra Kenneth Hoffman, Ray Kunze. Second Edition, Pearson Publications 2. Matrices and Linear Transformations Charles G Cullen, 2nd Edition, Dover Publications, NY

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CODE : UMAT-401 **Real Analysis** **Credits 3**

Course Objectives: It will introduce students to real functions, their limit, continuity and differentiability. It will introduce students to Riemann integrals, sequences and series of functions.

Course Outcomes:

(i) Understanding limit, continuity and differentiation of real functions using abstract approach.

(ii) Understanding the concept of integration via Riemann Integrals.

(iii) Understanding the difference between Point wise and Uniform convergence of sequences and series of real functions and use of convergence tests.

Content:

S.no	TOPIC	
1	**Limit and Continuity** Limit of a function and Limit theorems Continuous functions Properties of Continuous functions Uniform continuity	**12 periods**
2	**Differentiation** The Derivatives Mean Value theorem and application L'Hospital's rule for finite and Infinite Cases Taylor's theorem	**10 periods**
3	**Integration** Riemann Integrals Properties of Definite Integrals Fundamental Theorems of Integral Calculus	**10 periods**
4	**Sequences and series of functions** Sequence of functions Pointwise and Uniform Convergence Uniform convergence of Power Series	**10 periods**
	Total	**42 periods**

Key Text(s) Analysis – An Introduction to Proof
Steven R Lay – Prentice Hall 5th Edition

Coverage of Key Text(s) Chapters: 5(except section 5.5), 6, 7, 9(except section 9.2)

References: Introduction to Real Analysis
Robert G Bartle, Donald R Sherbert, 4th Edition, Wiley publications

CODE : UMAT- 402 **Algebraic Structures I** **Credits 3**

Course Objectives: It will introduce students to Groups and Rings. It familiarizes students to isomorphism between groups. It will introduce students to cosets of a subgroup in a group.

Course outcomes:

(i) Understanding the abstract structure 'Groups', its Subgroups, cyclic Groups and Permutation Groups

(ii) Understanding of order of group and order of element.

(iii) Understanding the concept of isomorphisms between groups.

(iv) Understanding the concept of cosets. Lagrange's Theorem and its Applications.

(v) Understanding the structure 'Rings' and some special type of rings.

Content:

S.no	TOPIC	
1	**Group** Definitions, Examples, Elementary Properties.	**5 Periods**
2	**Finite groups and Subgroups** Terminology and notation, Subgroup tests	**5 Periods**
3	**Cyclic Groups** Properties of Cyclic Groups, Classification of Subgroups of Cyclic Groups	**5 Periods**
4	**Permutation Groups** Definition, Cycle notation, Properties of Permutations (Except examples related to Tetrahedron, sliding disk, Rubik's Cube)	**4 Periods**
5	**Isomorphisms** Definition and Examples, Cayley's Theorem, Properties of Isomorphisms, Automorphisms	**5 Periods**
6	**Cosets and Lagrange's theorem** Properties of Cosets, Lagrange's theorem and its consequences (Except applications related to Cube, Soccer ball, Rubik's Cube)	**4 Periods**
7	**Definition of Rings** Definition, Motivation, Examples, Properties	**6 Periods**

8	**Integral Domains and Fields** Definitions, Examples, Fields, Characteristics of a Ring	**8 Periods**
	Total	**42 Periods**

Key Text(s) Contemporary Abstract Algebra
Joseph A. Gallian, 8th Edition, Cengage Learning

Coverage of Key Text(s) : Chapters: 2 to 7, 12 and 13.

- **Problems in exercises that involve internal and external direct product are to be omitted .**

References: Abstract Algebra
John B Fraleigh, 7th Edition, Pearson Publications

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CODE: UMAT- 501 Complex Analysis CREDITS 4

Course Objectives: It introduces students to complex variables and functions complex variables. It familiarizes students to limit, continuity, differentiability and analyticity of functions of a complex variable. It introduces students to integration of function of a complex variable and Cauchy Theorem. Concept of convergence is introduced. It introduces students to singularities and residues and their applications. Fractional linear transformations conformal mappings are introduced.

Course Outcomes:

(i) Understanding properties of Complex Numbers and functions of a complex variable.
(ii) Understanding the concept of limit, continuity, differentiability and analyticity of functions of complex variable.
(iii) Understanding of some elementary functions of a complex variable
(iv) Understanding the concept of Integration of functions of complex variable along a contour and Cauchy- Goursat Theorem.
(v) Understanding the convergence of sequences and series of complex numbers. Taylor and Laurent series expansion of functions.
(vi) Understanding the concept of singularities and residue at a singular point and applications of residues in evaluation of certain type of Improper Integrals.
(vii) Understanding Linear Fractional Transformations and Conformal Mappings.

Content:

S.no	TOPIC	
1	**Complex Numbers** Over View of Algebra of Complex Numbers	**2 periods**
2	**Analytic Functions** Complex Function Limits – Continuity – Differentiability Analyticity - Harmonic Functions	**8 periods**
3	**Elementary Functions** Definition and Properties of Exponential, Trigonometric, Hyperbolic, Logarithmic, Inverse Trigonometric and Inverse Hyperbolic Functions and Complex Exponents	**8 periods**
4	**Integration** Integral of Complex Valued Functions Contour Integration - Anti-Derivative Cauchy-Goursat Theorem Cauchy Integral Formula Derivative of Analytic Function and Related Results.	**14 periods**

5	**Series**	**8 periods**
	Convergence of Sequence and Series Taylor Series - Laurent Series Integration and Differentiation Of Power Series Uniqueness of Series.	
6	**Singularities and Residues**	**8 periods**
	Residue and Residue Theorems Types of Isolated Singularities Residue at Singularities Evaluation of Improper Integrals only of Rational Functions and Functions Involving Sine and Cosine.	
7	**Transformations**	**5 periods**
	Elementary Transformations Linear Fractional transformations Mapping of regions	
8	**Conformal Mappings**	**3 periods**
	Preservation of Angles and other Properties	
	Total	56 **periods**

Key Text(s)	Complex Variables and Applications. J.W. Brown and R. Churchill, McGraw Hill Pub.6th Edition (1966).
Coverage of key text	Ch.1 To 3, Ch.4 (Except Section 37), Ch.5 (Except Sections 48 and 52), Ch.6, Ch.7 (Sections 60 to 62), Ch.8 (Except Sections 75 To 78), Ch.9 (Sections 79 And 80).
References	Basic Complex Analysis Jerrold E Marsden, Michael J. Hoffman, 3rd Edition, W.H Freeman Publications, NY

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CODE : UMAT -502 **Topics in Linear Algebra** **Credits 4**

Course Objectives: It will introduce students to concept of scalar product on a Vector space. It will familiarize students to Spectral Theorem and Diagonalization of Linear Transformations. It will introduce students to Jordan Normal form and its applications.

Course Outcomes:

(i) Understanding the concept of norm and orthogonality in Inner Product spaces.

(ii) Understanding the concept of isometry in Inner Product spaces.

(iii) Understanding the Spectral Theorem and its applications in the Diagonalization of Linear Transformations.

(iv) Understanding the concept of Jordan Canonical form of Linear Transformations.

(v) Understanding Cayley Hamilton Theorem and its applications.

(vi) Understanding the application of Jordan Normal Form in solving Linear Differential Systems.

Content:

S.no	TOPIC	
1	**Inner Product Spaces** Scalar Products, Inner Product Spaces, Isometries, The Riesz Representation Theorem	**13 periods**
2	**Spectral theorem and Quadratic forms** Self-Adjoint Transformations, Diagonalization Theorems, The Spectral Theorem, The Principal Axis Theorem for Quadratic Forms, A Proof of the Spectral Theorem in the General Case	**16 periods**
3	**Jordan Canonical form** Invariant Subspaces, Nilpotent Transformations, The Jordan Normal Form, Square Roots, The Hamilton-Cayley Theorem, Inverses	**15 periods**
4	**Application to Differential Equations** Linear Differential Systems: Basic Definitions, Diagonalizable Systems, Application of Jordan Form	**12 periods**
	Total	**56 periods**

Key Text(s) Linear Algebra
Larry Smith, UTM Springer-Verlag, 3rd edition

Coverage of Key Text(s) Book: Chapters 14 (Only 14.5), 15 (except 15.5), 16,17,18.

References: **1.** Linear Algebra
Kenneth Hoffman, Ray Kunze. Second Edition, Pearson Publications.
2. Matrices and Linear Transformations
Charles G Cullen, 2nd Edition, Dover Publications, NY

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CODE: UMAT- 503 TOPOLOGY Credits 4

Course Objectives: It introduces students to Metric and Topological spaces and subspaces It familiarizes students to the concept of convergence,

Course Outcomes:

(i) Understanding Metric Spaces and convergence of sequences, completeness and continuous functions in Metric Spaces.

(ii) Understanding of Topological spaces and concept of Base and open Subbase.

(iii) Understanding the concept of product offinite and arbitrary Topological Spaces.

(iv) Understanding the concept of compactness, Separation and connectedness in Metric and Topological Spaces.

Content:

S. no	TOPIC	
1	**Metric Spaces**	**15 Periods**
	Definitions and examples Open Sets Closed Sets Convergence of a Sequence, Completeness, Baire's Theorem Continuous Mapping Spaces Of Continuous Functions Euclidean And Unitary Spaces	
2	**Topological Spaces**	**10 Periods**
	Definitions and examples Elementary concepts Open Base and Subbase Weak Topology	
3	**Compactness**	**15 Periods**
	Products of Spaces Tychonoff Theorem & Locally Compact spaces Compactness for Metric Spaces	
4	**Separation**	**8 Periods**
	T_i-Spaces and Hausdorff spaces Completely Regular Space and Normal Space Urysohn's Lemma Tietze Extension Theorem	

5	**Connectedness**	**8 Periods**
	Definitions and Examples Connected Spaces Components of a Space Totally Disconnected Spaces Locally Connected Spaces	
	TOTAL	**56 periods**

Key Text(s)	**An Introduction to Topology and Modern Analysis.** G. F. Simmons, McGraw Hill International
Coverage of Key Text	Chapters 2, 3 (*except* section 20), 4, 5 (*except* sections 29, 30), 6.
References:	**Topology** James Munkers, 2nd Edition, Pearson Publications

CODE : UMAT-601 Algebraic Structures II Credits 4

Course objectives: It introduces students to normal subgroups, factor groups and factor rings. It introduces students to homomorphisms of group and rings. It introduces students to polynomial rings, unique factorization domains and Euclidean domains. It familiarize students to divisibility and prime elements. It gives an introduction to field extensions and algebraic extensions. Sylow's Theorems were introduced to know the possible structure of group of certain order.

Course Outcomes:

(i) Understanding of Normal subgroups, Factor groups, ideals of rings and factor rings.

(ii) Understanding the concept of homomorphism in Groups and Rings.

(iii) Understanding of Polynomial rings and factorization in polynomial rings.

(iv) Understanding the concept of divisibility in Integral domains and prime elements of integral domain. It gives the understanding of Unique Factorization Domains and Euclidean domains.

(v) Understanding Field extensions and Algebraic extensions and their properties.

(vi) Understanding of how Sylow's Theorems can be used to find possible structures of a group, given the order of the group.

Content:

S.no	TOPIC	
1	**Normal Subgroup and Factor Group** Definitions and Applications (Exclude Internal Direct Products)	**5 Periods**
2	**Group Homomorphism** Definition and Examples. Properties of Homomorphisms, The First Fundamental Theorem of Isomorphism	**6 Periods**
3	**Ideals and Factor Rings** Definition, Examples, Prime Ideals, Maximal Ideals	**6 periods**
4	**Ring Homomorphisms** Definition, Examples, Properties, Field of Quotients	**5 Periods**
5	**Polynomial Rings** Notation and terminology, The Division Algorithm and its consequences.	**5 Periods**
6	**Factorization of Polynomials** Reducibility Tests, Irreducibility Tests Unique Factorization in Z[x] and its applications	**6 Periods**

7 Divisibility in Integral Domains **5 Periods**

Irreducible and Prime elements in Integral Domains,
Unique Factorization Domains, Euclidean Domains

8 Extension Fields **5 Periods**

The Fundamental Theorem of Field Theory (Kronecker's Theorem related to Extension Fields), Splitting Fields, Zeros of Irreducible Polynomials

9 Algebraic Extensions **5 Periods**

Characterization of extensions (Algebraic, transcendental extensions), Finite extensions, Properties of Algebraic extensions

10 Sylow's Theorems

Conjugacy Classes, The Class Equation, Applications of Sylow's Theorem **8 Periods**

Total **56 Periods**

Key Text(s) Contemporary Abstract Algebra
Joseph A. Gallian, 8th Edition, Cengage Learning

Coverage of Key Text(s) Chapters: 9, 10, 14, 15, 16, 17, 18, 20, 21, 24

Problems in Exercises that involve internal and external direct product are to be omitted.

References :

1. Abstract Algebra
John B Fraleigh, 7th Edition, Pearson Publications
2. Algebra in Action: A Course in Groups, Rings and Fields
Shahriar Shahriari, American Mathematical Society

UMAT-602 Numerical Methods Credits 4

Course Objective: It introduces students to numerical methods which can be used to obtain approximate solutions to certain problems and bound of error in approximation. It familiarizes students to algorithmic methods for finding approximate (i)solution of nonlinear equations(ii) solutions of problems related to differentiation and integration (iii) finding eigenvalues and eigenvectors and solution of system of linear equations (iv) solutions of initial-value problems. It familiarizes students to convergence analysis of these methods.

Course outcomes:

(i) Understanding of how Numerical Methods can be used to find approximate solutions and study of error by approximation.

(ii) Understanding the use of numerical methods for finding approximate root of algebraic equations

(iii) Understanding how a function whose values at certain points is given can be approximated by polynomial through polynomial interpolation,

(iv) Understanding of methods of solving problems related to integration and differentiation.

(v) Understanding the use of algorithms for finding approximate(a) eigenvalues and eigenvectors of a matrix (b) solution of a system of equations.

(vi) It gives an understanding of how to solve an Initial-Value problem using numerical methods.

Content:

1 Taylor Polynomial 4 Periods
Taylor Polynomial - Remainder Term - Methods of Polynomial Evaluation

2 Error and Floating Point Arithmetic 4 Periods
Floating Point Representation of Numbers - Floating Point Arithmetic - Errors - Propagation of Error

3 Roots of Algebraic Equations 8 Periods
Bisection Method - Newton Method - Secant Method - Fixed Point Method.

4 Polynomial Interpolation 10 Periods
Linear and Quadratic Lagrangian Interpolation Formulas - Divided Differences - Newton's Divided Difference Interpolation Formula - Error in Polynomial Interpolation - Spline Interpolation using Linear, Quadratic and Cubic Splines

5 Integration And Differentiation 10 Periods
Trapezoidal Rules - Simpson Rules - Error Formulas - Gaussian Integration - Differentiation by Interpolation - Differentiation by the Method of Undetermined Coefficients - Effects of Error in Function Values

6 Matrices and Systems of Linear Equations 9 Periods

Review of Matrix Arithmetic - Gaussian Elimination Method - Partial Pivoting - Operations Count - Inverse of a Matrix - LU Factorization of a Matrix - Doolittle's Method - Tridiagonal Systems - Error in Solution - Residual Correction Method - Stability and Condition Number - Iteration Methods

7 Eigen Values and Eigen Vectors 3 Periods

Method of Least Squares - Linear and Polynomial Approximation of Data - Review of Eigen Value and Eigen Vector Theory - Power Method

8 Ordinary Differential Equations 8 Periods

Euler's Method - Convergence Analysis of Euler's Method - Taylor Method - Runge-Kutta Methods

Total 56 periods

Key Text(s) **Elementary Numerical Analysis, 3rdEdn.**
Kendall Atkinson &Weimin Han, Wiley India

Coverage of Key Text

Chapters 1 (*except* sub-Section 1.2.1), 2 (*except* Section 2.4),
3 (except 3.5), 4 : Sections 4.1, 4.2, 4.3 (*except* sub-Section 4.3.3)
5 : Sections 5.1, 5.2 (*except* sub-Section 5.2.4), 5.3 and 5.4, 6,
7: Sections 7.1 and 7.2, 8 : Sections 8.2, 8.3, 8.5 (*except* sub-Section 8.5.2)

Note: Algorithms and their programming implementations are excluded. However, the algorithms may be considered for testing in CIE.

References: Numerical Analysis
Richard Burden, J Douglas Faires, 9th Edition,
Thomson Publications

CODE: UMAT-603 Methods of Differential Equations Credits 4

Course Objectives: It introduces students to power series methods. Bessel and Gamma functions are introduced, It familiarizes students with the method of separation of variables for solving certain problems of Mathematical Physics. It introduces students to Sturm Liouville boundary value problems and their solutions.

Course Outcomes:

(i) Understanding power series method for solving differential equations of first and second order.

(ii) Understanding Bessel functions and Gamma functions as the solutions of certain differential equations.

(iii) It gives an understanding of how the Method of separation of variables can be used to find Fourier Series solutions of Heat Equation, Wave Equation and Laplace Equation.

(iv) Understanding the significance of Sturm Liouville Boundary Value Problems. Understanding of Bessel series expansion, Expansion in terms of orthogonal functions and Mean convergence.

Contents:

S.no	TOPIC	
1.	**Power Series Solutions and Special Functions** Introduction – A review of power series Series solutions of first order equations Second order linear equations – ordinary points Regular singular points Gauss's Hypergeometric equation	**16 periods**
2.	**Some special functions of mathematical physics** Bessel functions – The Gamma function – and their properties	**6 periods**
3.	**Partial Differential Equations and Fourier Series** Two-point boundary value problems Fourier Series The Fourier convergence theorem Even and odd functions Separation of variables – heat conduction in a rod The wave equation – vibrations of an elastic string Laplace's equation	**20 periods**
4.	**Boundary Value Problems and Sturm-Liouville Theory** The occurrence of two-point boundary value problems Sturm-Liouville boundary value problems. Non-homogeneous boundary value problems. Further remarks on the method of separation of variables – A Bessel series expansion Series of orthogonal functions – mean convergence	**14 periods**
	Total:	**56 periods**

Key Text(s) (i) Elementary Differential Equations and Boundary Value Problems
William E. Boyce & Richard C. DiPrima, 10th edition, 2012, John Wiley & Sons

(ii) Differential Equations with Applications and Historical Notes
George F. Simmons, John S. Robertson McGraw Hill, 2nd edition, 1991.

Coverage of Key Text(s) Book 1: Chapters: 10 (except 10.6), 11 (except 11.4)
Book 2: Chapters: 5 (except appendices and section 32), 8(only sections 46 and 47 without appendices)

References: 1. Differential Equations and Boundary Value Problems
C Henry Edwards, David E Penney, 3rd Edition, Pearson Publications.
2. Ordinary Differential Equations, Tyn Myint U, 1978, Elsevier North-Holland

Syllabus for Elective Courses

GEOMETRY

UG Elective Code: UM-1 **Credits 3** **42 Periods**

Course Objectives

The course introduces the knowledge and understanding of plane and solid geometry, Projective Geometry, spherical geometry.

Course Outcomes:

After the course, students

- Learn the main elements of Projective Geometry.
- Should be able to view affine geometry as a local aspect of the projective environment.
- Will be familiar with the study of elementary properties of algebraic curves in real and complex projective plane.
- Will be able to apply the geometrical skills to solve simple real-world problems.
- Could develop technical skills in sketching and drawing.

S.no	TOPIC
1	**Geometry of Numbers** **9 Periods** Natural Numbers, Adding Natural Numbers, Multiplying Natural Numbers, Squaring and Triangular Numbers, Powers, Zero and Negative Numbers, Rational Numbers or Fractions, Powers of Rational Numbers, Rational Numbers as a Field, Real Numbers, Irrational Numbers, Fours famous numbers: $\sqrt{2}, \pi, \tau$ and e.
2	**Co-ordinate Geometry of R^n** **9 Periods** Coordinates,$\boldsymbol{R^n}$ the space of coordinates, the line through two points, the plane containing three points, distance and angle, polar coordinates, area, hyperplanes, angle between hyperplanes and nearest points to hyperplanes.
3	**Solid Geometry** **8 Periods** Points and Coordinates, Scalar Product, Cross Product, The Scalar Triple Product, The Vector Triple Product, Planes, Lines in Spaces, Isometries of Space, Projections, Polyhedra.

4	**Projective Geometry**	**8 Periods**
	The Projective Plane, Line in the Projective Plane, Incidence and Duality, Desargues' Theorem, Cross Rations and Duality, Projectives and Perspectives, Quadrilaterals, Projective Transformations, Fixed Points and Eigenvectors, Pappus' Theorem, Perspective Drawing: Traicks of the Trade, The Fano Plane.	
5	**Spherical Geometry**	**8 Periods**
	Geodesics, Geodesic Triangles, Latitudes and Longitude, Compass Bearings, The Celestial Sphere, Observer's Coordinates, Time and Right Ascension	
	Total	**42 Periods**

Key Text(s)	Geometry by Roger Fenn, Springer Undergraduate Mathematical series, 1st edition, (2003).
Coverage of key text	Chapters 1, 2, 5, 6 and 8.
References:	Geometry Through History: Euclideann Hyperbolic, and projective Geometry, Meighan I Dillon, springer

COMBINATORICS

UG Elective Code: UM-2 **Credits 3** **42 Periods**

Course Objective:

- Identify and apply underlying combinatorial structures and analyze them.
- Learn fundamental combinatorial structures that naturally appear in various other fields of mathematics and computer science.

Course Outcomes:

After completing this course, students will have the knowledge of

- Counting principles in our daily lives.
- The science behind combinations of discrete items.
- Generating functions.
- Pigeon hole principle, inclusion and exclusion principles, Polyas counting based on group theory.

S.no	TOPIC	
1	**Classical Techniques** Basic Combinatorial Numbers Generating Functions and Recurrence Relations Symmetric Functions Multinomials Inclusion and Exclusion Principle Permutations With Forbidden Positions	**12 Periods**
2	**Polya Theory** Necklace Problem and Burnside's Lemma Cycle Index of a Permutation Group Polya's Theorem and Its Immediate Applications	**15 Periods**
3	**Matching Theory and Inversion Techniques** Review on Partially Ordered Sets Basic Existence Theorems Classical Inversion Formulas & Inversion via Mobius Function	**15 Periods**
	Total	**42 Periods**

Key Text(s)	**Combinatorics - Theory and Applications,** V Krishnamurthy Affiliated East - West Press Pvt. Ltd., (1985).
Coverage of key text	Ch. I; Ch. II: Sec 1, 2 and 3; Ch.VI and Ch.VII: Sec, 1 and 2.
References:	A Course on Combinatorics J H Van Lint, R M Wilson, 2nd Edition, Cambridge University Press

ELEMENTARY NUMBER THEORY

UG Elective Code: UM-3 **Credits 3** **42 Periods**

Course Objective:

- Learn certain number theoretic functions and their properties.
- Understand the concept of congruence and learn various results related to congruence including the Chinese Remainder Theorem.
- Solve certain types of Diophantine equation.
- Identify how Number Theory is related to Cryptography.

Course Outcomes:

Students will be able to

- Learn methods and techniques used in Number Theory.
- Apply different methods of proofs to verify mathematical assertions including proof by induction, by contrapositive, and by contradiction.
- Solve system of Diophantine equation using the Chinese Remainder theorem and Euclidean algorithm.
- Use Fermat Theorem, Euler function in Cryptography.

S.no	TOPIC	
1	Divisibility Theory of Integers - Primes and Their Distribution	5 Periods
2	The Theory of Congruence	5 Periods
3	Fermat's (Little) Theorem	5 Periods
4	Number Theoretic Functions	6 Periods
5	Euler's Generalization of Fermat's Theorem	6 Periods
6	Primitive Roots to Prime Modulus	6 Periods
7	The Quadratic Reciprocity Law (Excluding Quadratic Residues to Composite Moduli)	6 Periods
8	Perfect Numbers	3 Periods
Total		42 Periods

Key Text(s): Elementary Number Theory
David M Burton, Third Edition, W C Brown Publishers,(1994)

Coverage of key text : Sec. 2.1 to 2.4, 3.1 to 3.3, 4.1 to 4.4, 5.1 to 5.4,6.1 to 6.3, 7.1 to 7.5, 8.1 To 8.2, 9.1 to 9.3 and 10.1.

References: A Classical Introduction to Modern Number Theory
Kenneth Ireland, Michael Rosen, 2nd Edition, Springer.

GRAPH THEORY

UG Elective Code : UM-4 **Credits 3** **42 Periods**

Course Objectives:

The main objectives of this course are

- To understand the fundamental concepts in graph theory.
- To apply graph theory concepts in solving practical problems.
- Some of the topics covered in this course are bipartite graphs, Euler graphs, Hamiltonian graphs, Connectivity, planar graphs, Coloring of a graph.

Course Outcomes:

After the completion of the course,

- Students will have a strong background of graph theory which has diverse applications in the areas of computer science, biology, chemistry, physics and engineering.

S.no	TOPIC	
1	**Introduction** Graphs and Graph model, Connected graphs, Multi graphs and Digraphs	**4 Periods**
2	**Degree** Degree of a vertex, Regular graph, Degree sequence	**5 Periods**
3	**Isomorphism of graphs** Definition of isomorphism, Isomorphism as a relation	**5 Periods**
4	**Connectivity** Cut-vertices, Blocks, Connectivity	**7 Periods**
5	**Transversability** Eulerian graph, Hamiltonian graph	**7 Periods**
6	**Planarity** Planar graph, Embedding planar graphs on surface	**7 Periods**
7	**Coloring** Color Problem, Vertex Coloring	**7 Periods**
	Total	**42 Periods**

Key Text(s) Introduction to Graph Theory (reprint), Gary Chartrand, Ping Zhang, Tata McGraw Hill.

Coverage of key text	Ch. 1, Ch.2: Sec 2.2 to 2.3, Ch. 3: Sec3.1 to 3.2, Ch.5 : Sec 5.1 to 5.4, Ch. 6: Sec 6.1 to 6.2, Ch. 9: Sec 9.1 to 9.2,Ch. 10: Sec 10.1 to 10.3 .

References: Introduction to Graph Theory

Douglas B West, @nd Edition, Pearson Publications

CONTINUUM MECHANICS

UG Elective Code : UM-5 **Credits 3** **42 Periods**

Course Objectives:

- To learn the basic notion and rules of tensor calculus.
- To develop problem solving skills, applying the conservation principles and the constitutive equations to solve real life problems.
- Learn elastic and plastic behaviour of materials.

Course Outcomes:

On successful completion of the course students will be able to

- Use tensor algebra and calculus for derivations in general coordinates.
- Understand the concepts of various deformations and stress tensors.
- Derive the equations of conservation of mass, momentum and energy.
- Use the theory to formulate and solve problems in linear and nonlinear elasticity and compressible and incompressible fluid mechanics.

S.no		TOPIC
	1	**Introduction** **2 Periods**
	2	**Vectors and Cartesian Tensors** **5 Periods** Vectors, Coordinate transformations, Dyadic product, Cartesian tensors, Isotropic Tensors, Multiplication of tensors, Tensor and matrix notation, Invariants of a second order tensor, Deviatoric tensors, tensor and vector calculus
	3	**Particle Kinematics** **5 Periods** Bodies and their configurations, Displacement and velocity, Time rates of change, Acceleration, Steady motion, Particle paths, Streamlines
	4.	**Stress** **5 Periods** Surface traction, components of stress, Traction on any surface, Transformation of stress components, equations of equilibrium, Principal stress components, Principal axes of stress, Stress invariants, Stress deviator tensor, Shear stress, Simple states of stress

	5	**Motions and Deformations** **5 Periods** Rigid body motions, Extensions of a material line element, Deformation gradient tensor, Finite deformation and strain tensors, Simple finite deformations, Infinitesimal strain, Rate-of-deformation tensor, Velocity gradient and spin tensors, Simple flows	
	6	**Conservation Laws** **5 Periods** Conservation laws of physics, Conservation of Mass, Material time derivative of a volume integral, Conservation of linear momentum, angular momentum and energy, Principle of virtual work	
	7	**Linear Constitutive Equations** **5 Periods** - Constitutive Equations and ideal materials, Material symmetry, Linear elasticity, Newtonian viscous fluids, Linear viscoelasticity	
	8	**Analysis of Finite Deformations** **5 Periods** Deformation of a surface element, Decomposition of a deformation, Principal stretches and axes of deformation, Strain invariants, alternative stress measures	
	9	**Non-Linear Constitutive Equations** **5 Periods** Non-linear theories, Theory of finite elastic deformation, A non-linear viscous fluid, Non-linear viscoelasticity, Plasticity	
		Total	**42 Periods**

Key Text(s)	Continuum Mechanics. A J M Spencer. Longmann Pub. London (1980)
Coverage of Key Text	Ch. 1, Ch. 3 To Ch. 10
References:	A First Course in Continuum Mechanics Y.C. Fung, Prentice Hall, Third Edition.

OPERATIONS RESEARCH

UG Elective Code: UM-6 **Credits 3** **42 Periods**

Course Objectives:

The aim of this subject is to provide a student with

- A broad and in depth knowledge of a range of operation research models and Techniques, which can be applied to a variety of industrial applications.
- Decision theory and game theory techniques, detailed knowledge of inventory models and queuing theory.

Course Outcomes

After completing the course, students will be able to

- Apply various Methods for solving different operations research models.
- Use suitable procedures for various queuing problems.
- Investigate various procedures for different games (game theory).
- Investigate Various Inventory models.

S.no	TOPIC	
1	**Decision Theory**	**5 Periods**
	Decision under Risk - Decision Trees - Decision under Uncertainty.	
2	**Game Theory**	**6 Periods**
	Two Person Zero Sum Game-Mixed Strategies-Solutions by Graphical Methods and Linear Programming.	
3	**Inventory Models**	**16 Periods**
	A Generalized Method - Deterministic Models (Single Item Static Model with and Without Price Break - Multiple Item Static Model With Storage Limitation And Multi Period Production Scheduling Model) - Probabilistic Models (Continuous Review Model-Single And Multi Period Models).	
4	**Queuing Theory**	**15 Periods**
	Basic Elements of Queuing Model-Arrival And Departure Processes-Queues With Combined Arrivals And Departures ((M/M/1):Gd/00/00),(M/M/1):(Gd/N/00),(M/M/C):(Gd/00/00) and (M/M/00 : (Gd/00/00)) - Queues With Priorities For Service ((M/G/1): (Nprp/00/00) and (M/M/C):(Nprp/00/00).	
	Total	**42 periods**

Key Text(s) Operation Research
Hamdy A Taha, Macmillan Pub., N. Y., 4th Edition, (1989).

Coverage of key text Ch.11, 13 (Except 13.3.4), 15(15.1 To 15.4 except 15.3.5 and 15.3.7)

References : Introduction to Operations Research

Frederick S.Hittier, Gerald J Liberman, Bodhibrata Nag, Preetam Basu

Tata Mc.Graw Hill, New Delhi.

LINEAR PROGRAMMING

UG Elective Code : UM-7 Credits 3 42 Periods

Course Objectives:

- Define and formulate linear programming problems.
- Solve linear programming problems using appropriate techniques and interpret the results obtained.
- Conduct and interpret post-optimal and sensitivity analysis and explain the primal-dual relationship.
- Develop mathematical skills to analyse network models arising from a wide range of applications.

Course Outcomes:

On successful completion of the course students will be able to

- Explain what a linear optimization problem is and how it can be saved.
- Analyze solutions to linear optimization problem and interpret the results.
- Solve transportation models and assignment models used in business.

S. No TOPIC

1. **Graphical Method** **4 Periods**
   Two-Variable LP Model - Graphical Solution

2. **Algebraic Methods** **12 Periods**
   Simplex Method - Artificial Starting Solution : Big M-Method - Two-Phase Method - Special Cases in Simplex Method - Sensitivity analysis

3. **Duality** **8 Periods**
   Dual Problem - Primal-Dual Relationships - Dual simplex method & generalized simplex method - Post optimal analysis

4. **Transportation Models** **9 Periods**
   Transportation Algorithm - Assignment Model: Hungarian - Method - Transshipment Model - Simplex Method Explanation Of the Method of Multipliers - Simplex Explanation of the Hungarian Method

5. **Network Models** **9 Periods**
   Network definitions - Minimal Spanning Tree - Shortest-Route in a Network: Dijkstra's Algorithm - Floyd's Algorithm - Maximal Flow model- Linear Programming Formulation of Shortest Route Problem, Linear

Programming Formulation of Maximal Flow

Total	**42 Periods**
Key Text(s)	Operations Research - An Introduction Hamdy A. Taha, 8th Ed, Pearson (2002)
Coverage of Key Text	Chapters 1, 2: 2.1 to 2.2, 3, 4, 5, 6: 6.1 to 6.

References:

Introduction to Operations Research

Frederick S.Hittier, Gerald J Liberman, Bodhibrata Nag, Preetam Basu

Tata Mc.Graw Hill, New Delhi.

INTRODUCTION TO CODING THEORY

UG Elective Code: UM-8 **Credits 3** **42 Periods**

Course Objectives:

- Introduce coding and uses of coding.
- Discuss simple error models, Hamming distance.
- Introduction to finite fields and vector spaces.
- Introduce linear codes in terms of generator and parity-check matrices. Discuss decoding of linear codes Coset's. Analyze the performance of linear codes in terms of weight enumerator functions.
- Derive classical bounds on the number of code words, the minimum distance, and the length of code. This will include the Gilbert bound, the Varshamor bound, the Hamming bound, and the Singleton bound.

Course Outcomes:

On successful completion of the Coding Theory course, students should be able to:

- State and prove fundamental theorems about error-correcting codes given in the course.
- Calculate the parameters of given codes and their dual codes using standard matrix and polynomial operations.
- Encode and decode information by applying algorithms associated with well-known codes.
- Compare the error-detecting/correcting facilities of given codes

S.No.	TOPIC	
1	**Introduction**	**1 Period**
2	**Error detection, Correction and Decoding** Communication Channels – Maximum Likelihood decoding – Hamming distance Nearest Neighbor / Minimum distance decoding	**6 Periods**
3	**Finite Fields** Overview of Fields and Polynomial Rings-Structure of finite fields-Minimal Polynomials	**6 Periods**
4	**Linear Codes** Vector Spaces over finite fields-Linear Codes Hamming Weight-Bases for Linear Codes- Generator Matrix and Parity Check matrix Equivalence of Linear Codes Encoding with a Linear Code Decoding of Linear Codes Coset's Nearest Neighbor decoding for Linear Codes-Synchronous decoding	**12 Periods**

5	**Bounds in Coding Theory** Main Coding Theory Problem-Lower Bounds-Sphere Covering Bound Golenert Varshamor Bound – Hamming Bound and Perfect Codes Binary Hamming Codes q-ar, Hamming Codes-Golay Codes Singleton Bound and MOS Codes – Plotkin bound.	**10 Periods**
6	**Constructions of Linear Codes** Propagation Rules-Read Muller Codes	**7 Periods**
Total		**42 Periods**

Key Text(s) Coding Theory, A First Course

SAN LING, CHOPING XING,

Cambridge Institute of Higher Learning Press (2004)

Coverage of key text Chapters 1 to 5 (except 3.1, 3.2, 5.6, 5.7and 5.8, 6.3)

Reference Text(s)

1. Introduction to Coding Theory

R.M. Roth – Cambridge Press, UK (2006)

2. Introduction to Coding Theory

H. VanLint, Springer, (1998)

3. Coding theory and Cryptography: The Essentials

D.C. Hankerson et.al, Marcell Dekker Inc. (2000)

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Discrete Mathematics

UG Elective Code: UM-9 **Credits 3** **42 Periods**

Course Objectives:

- Understand the notion of mathematical thinking, mathematical proofs, and be able to apply them in problem solving.
- The focus of this course is on basic mathematical concepts in discrete mathematics and on applications of discrete mathematics in algorithms and data structures.
- To show students how discrete mathematics can be used in modern computer science (with the focus on algorithmic applications).

Course Outcomes:

On completion of the course, students will be familiar with

- Constructing proofs.
- Elementary logic, recurrence relations.
- Graphs and trees, relations and functions, partial order relations and lattices and their uses in computer science.

S.no **TOPIC**

1. **Relations and Digraphs** **12 Periods**
   Product Set, Partition, Relation, Digraph, Path, /equivalence relation, Computer representation of operations on relations, Transitive closure, Warshall's algorithms

2. **Functions** **6 Periods**
   Functions from computer science, Growth of functions, Primitive functions

3. **Order Relations and Structures** **12 Periods**
   Partially ordered set, External element, Lattice, Finite Boolean algebra, Circuit designs

4. **Trees** **12 Periods**
   Definition, Labeling, Searching, Directed tree, Minimal spanning tree
   Total **42 periods**

Key Text(s) Discrete Mathematical Structures
Kolman, Busby and Ross, Pearson Education, 4th edition.

Coverage of Key Text(s) Chapters: 4 to 7

References

1. Elements of Discrete Mathematics
C.L Liu, 4th Edition, Mc.Graw Hill
2. Discrete Mathematics for Computing
Rod Haggarty, Addison-Wesley, 2002

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UG Elective Code: UCS - 1 Introduction to Computer Science Credits 3

Course Objectives: This course will introduce students to what, why and how of algorithms. It familiarizes students about important problems of searching and sorting. It will introduce concepts of List, Stack and Queue along with few applications.

Course Outcomes:

i) Understand how to solve problem using algorithmic language.

ii) Understand how to represent information using different data types, use of decision constructs, functions, procedures, arrays, strings and sequential files in algorithms.

iii) Understand the searching algorithms like Linear search and Binary search

iv) Understand the sorting algorithms like Selection sort, Bubble sort, Merge sort and Quick sort.

v) Understand the composite data structures like Lists, Stack and Queues along with few applications.

Content:

S.no	TOPIC
1	**Algorithms** **4 Periods** Format - Syntax - Methodology And Language Of Algorithms – Data - Data Types - Primitive Operations - Variable Expressions.
2	**Decision Structures** **5 Periods** If-Then-Else - Nested If's - Different Type Of Loop Structures - Compound Conditions - Case Statement.
3	**Sub Algorithms** **6 Periods** Functions Procedures- Argument- Parameter Correspondence- Recursive Sub Algorithms.
4	**Composite Data Structures** **9 Periods** Vectors (One Dimensional Arrays) - Sorting And Searching of Vectors - Higher Dimensional Arrays – Structures - Arrays Of Structures - Introduction to Sequential Files.
5	**String Manipulation** **9 Periods** Character – Information - String Concepts - Operations on Strings.
6	**Linear Data Structures** **9 Periods** Linear List - Pointers - Sequential Storage Structures For Arrays - Stacks - Queues.
	Total **42 Periods**

Key Text(s): Introduction To Computer Science, An Algorithmic Approach
Jean Paul Trembley and Richard B. Bunt, McGraw Hill, 1981, Second International Edition.

Coverage of text: Ch. I to Ch.6, Ch. 8 (sec 8.1 to 8.6)

References: Introduction to Computer science: A Textbook for Beginners in Informatics

Gilbert Brands, CreateSpace Independent Publishing Platform, 2013

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UG Elective Code: UCS - 2 Fundamentals of Computer Systems Credits 3

Course Objectives: This course will introduce students to the fundamental concepts of computer organization and architecture. It is to familiarize students about hardware design including logic design, basic structure and behavior of the essential functional modules of the computer and how they interact to accomplish required processing for the needs of the user.

Course Outcomes:

i) Understand Boolean algebra as related to designing computer logic, through simple combinational and sequential logic circuits

ii) Understand how computers represent and manipulate data and convert between different number systems

iii) Understand basics of Instruction Set Architecture (ISA), basics of bus structure, input/output, memory, instruction and address flow, Characteristics of typical I/O devices and their functioning

Content:

Unit No.	Unit Title	Unit Contents	No. of Periods
1	Introduction to Digital Computer Logic	Boolean algebra, Gates and combinatorial logic, Sequential Logic circuits	8
2	Data Representation	Number systems – Physical Representation, Different Bases, Arithmetic in different bases, Numeric conversion between number bases, Hexadecimal numbers. Data Formats – Introduction, Alphanumeric character data. Representing Numerical data – Unsigned binary and binary-coded decimals, Signed integers, Real numbers.	10
3	Overview of Instruction set design and memory operations	Little Man computer – Layout, Operation, Programs, Instruction set, Instruction cycle. CPU & Memory – Components, Registers, Memory unit, Fetch-execute instruction cycle, Buses, Classification of instructions, Instruction word formats, Instruction word requirements and constraints. CPU& Memory design enhancement and implementation – CPU architectures, CPU Features and enhancements, memory enhancements. Instruction addressing modes – Register addressing, Immediate addressing, Indirect addressing, Register Indirect addressing, Indexed addressing, Indirect indexed addressing.	14
4	Input/output	Characteristics of typical I/O devices, Programmed I/O, Interrupts – Servicing, Uses, Multiple interrupts & Prioritization, Direct Memory access, I/O Modules	10
	Total		42 Periods

Key Text(s) : The Architecture of Computer Hardware and Systems Software: An Information Technology approach, Fourth Edition, Irv Englander, Publisher Wiley, 2009.

Coverage of key text: Ch 3 (3.0-3.6), Ch 4 (4.0-4.2), Ch 5 (5.0-5.3), Ch 6, Ch 7, Ch 8 (8.0-8.3), Ch9, 10(10.1,10.2) Supplementary chapter 1 and 3.

References: Introduction to Computer Systems, Haroldl Rogler, Kedall Hunt Publishing Company, 2015

UG Elective Code: UCS - 3 Data Structures and Algorithms Credits 3

Course Objectives: This course will introduce students to the fundamentals of algorithm analysis. It will familiarize with various Linear and Non-linear Abstract Data Types(ADT) like List, Stack, Queue and Trees. It will introduce greedy algorithm for finding Minimal Spanning Tree.

Course Outcomes:

i) Understanding of time complexity of simple algorithms.

ii) Knowledge of Linear Abstract Data Types(ADT) like List, Stack and Queue using Linked List in C programming language.

iii) Knowledge of various Non-linear Abstract Data Types(ADT) like Binary trees, Binary Search trees and AVL trees using C programming language.

iv) Understanding of sorting algorithms like Insertion Sort, Shell sort, Merge and Quick sort, Bubble sort and Selection sort.

v) Understand Topological linear ordering algorithm

vi) Knowledge of Prim's and Krushal's graph algorithm for finding minimal spanning tree.

Content:

S.no	TOPIC	
1	**Algorithm Analysis** Mathematical background – Model – What to Analyze.	**3 Periods**
2	**Lists, stacks and Queues** Abstract Data Types (ADT's) – The List ADT – The Queue ADT – The Stack ADT	**12 Periods**
3	**Trees** Preliminaries – Binary Trees – The Search Tree ADT – Binary Search Trees – AVL Tree	**10 Periods**
4	**Sorting** Preliminaries – Insertion Sort – Shell Sort – Merge Sort – Quick Sort.	**10 Periods**
5	**Graph Algorithms** Definitions – Topological Sort – Minimal Spanning Tree	**7 Periods**
	Total	**42 Periods**

Key Text(s):	1. Mark Allen Weiss , Data Structures and Algorithm Analysis in C, Pearson Education Pvt. Ltd., 2nd Edition

Coverage of key text	Ch 2 (2.1 to 2.3), Ch 3, Ch 4 (4.1.1, 4.1.2, 4.2.1, 4.2.2, 4.3.1 to 4.3.5, 4.4.1, 4.4.2), Ch 7 (7.1, 7.2.1, 7.4 (only the algorithm; 7.4.1 is excluded), 7.6 (only the algorithm; 7.6.1 is excluded), 7.7.1, 7.7.2, 7.7.3, 7.7.4), Ch 9 (9.1.1, 9.2, 9.5.1, 9.5.2). Two other basic sorting algorithms including Bubble sort and Selection sort should be briefed to the students
References	Introduction to Algorithms, Thomas H. Cormen, Charles E Leiserson, Ronald L. Rivest and Clifford Stein, PHI Learning Edition: 3rd Edition, 2010

UG Elective Code: UCS - 4 Mathematical Logic for Computer Science

Credits 3

Course Objectives: This course will introduce students about proof procedures which are methods of proving theorems or tautologies. Main objective of this course is to improve the reasoning skill.

Course Outcomes:

i) Skill to write simple mathematical proof without any supervision

ii) Given a problem to decide the design of a deductive process to find a solution

iii) Ability to resolve from a set of clauses

Content:

S.no	TOPIC	
1	**Introduction** The Origin of Mathematical Logic - Propositional And Predicate Calculus Theorem Provers and Logic Programming - Non-Standard Logics.	**9 Periods**
2	**Propositional Calculus** Boolean Operators - Propositional Formulas - Boolean Interpretations - Logical Equivalence And Substitution - Satisfiability, Validity And Consequence - Semantic Tableaux - Deductive Proofs - Resolution Variant Forms of Deductive Systems.	**11 Periods**
3	**Predicate Calculus** Relations and Predicates - Predicate Formulas – Interpretations - Logical Equivalence and Substitution – Functions and Terms - Clausal Form - Herbrand Models.	**11 Periods**
4	**Resolution and Logic Programming** Ground Resolution – Substitution – Unification – General resolution	**11 Periods**
	Total	**42 Periods**

Key Text(s)	**Mathematical Logic for Computer Science** M. Ben-Ari, Prentice Hall Pub.(1993)
Coverage of key text	Ch 1, Ch.2:2.1 To 2.7, 2.10 To 2.11, Ch.3:3.1 To 3.4, 3.7 To 3.9, Ch.4:4.1 To 4.4
References	Logic for Mathematics and Computer Science Stanley Burris, Prentice Hall, 1998.

UG Elective Code: UCS - 5 Design of Algorithms Credits 3

Course Objectives: This course will introduce students about different kinds of problems and data structures used in computer science. It will introduce timing analysis of algorithms. It will familiarize about different paradigms of designing algorithms.

Course Outcomes:

i) Introduction to algorithms, different kind of problems in computer science and data structures.

ii) Understand analysis of both recursive and non-recursive algorithms for efficiency.

iii) Understanding of different design paradigms of algorithms like Brute force approach, Divide & Conquer, Decrease & Conquer along with several examples.

iv) Knowledge of Horspool Algorithm and Boyer-Moore algorithm.

Content:

Unit 1: Introduction: Fundamentals of Algorithmic Problem Solving - Important Problem Types- Fundamental Data Structures, ADT (Stacks, Queues, Lists), Data Structures(Arrays, Linked lists, Double linked lists, Binary trees) **(6 Periods)**

Unit 2: Fundamentals of the Analysis of Algorithm Efficiency: Analysis Framework, Asymptotic Notations and Basic Efficiency Classes, Mathematical Analysis of Non-recursive and Recursive Algorithms **(5 Periods)**

Unit 3: Brute force and exhaustive search: Selection Sort, Bubble Sort, Sequential Search, String matching, Closest-Pair and Convex-Hull Problems by Brute Force, Traveling Salesman problem, Knapsack problem and Assignment problem, Depth first search and breadth first search **(12 Periods)**

Unit 4: Decrease-and-Conquer: Insertion Sort, Topological Sorting **(2 Periods)**

Unit 5: Divide-and-Conquer: Mergesort, Quicksort, Binary Search, Binary Tree Traversals and Related Properties, Multiplications of large integers and Strassen's Matrix multiplication **(12 Periods)**

Unit 6: Space and time trade-offs: Sorting by counting, Horspool Algorithm, Boyer-Moore algorithm. **(5 Periods)**

Total: **(42 Periods)**

Key Text(s) : Anany V. Levitin, Introduction to the Design & Analysis of Algorithms, 3rd Ed, Pearson (2011).

Coverage of key text: Ch1, ch2:2.1 to 2.5, ch3, ch4: 4.1:4.2; Ch5: 5.1 to 5.4; Ch7: 7.1 to 7.2

References: Introduction to Algorithms by Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, PHI Learning Edition: 3rd Edition, 2010

Course: UMAT-506 (Software Lab-I)

Course Title : Introduction to C Programming

Course Objectives:

Introduction to Linux commands, Input/Output using printf & Scanf and arithmetic operators, Conditional statements and relation operators, Use of while, for, do-while, break and continue, Functions, Arrays, Pointers and arrays, Strings.

Course Outcomes:

i) To be able to use basic linux commands.

ii) Understanding of basic Input, Output functions.

iii) Understanding of Arithemetic, Condtional, relational and logical operators.

iv) Understanding of if else, nested if else, switch case, different kinds of loops, break and continue.

v) Understanding of functions.

vi) Understanding of arrays and strings

UMAT-506: C Programming Lab-I; Credits:3			
Unit	Topic	Contents	Periods
1	Introduction to Linux commands	ls, cat, more, less, who, who am i, bc, gcc, cd, rm, cp, rmdir, mv	8
2	Input, output and arithmetic operators	Simple programs related to syntax of printf, scanf and arithemetic operators	8
3	Conditional statements and relation operator	Example problems based on if else, nested if else along with relation operators <,>,<=,>=,!=,==.	8
4	Use of while, for, do-while, break and continue	Simple problems based on while,do-while, for loop along with break and continue statements	16
5	Functions	Problems based on functions taking no, one or more arguments and returning zero or one value.	16
6	Arrays	1-D and 2-D Array problems for integer and real data type	8
7	Strings	Use of basic string functions	16

8	Introduction to Pointers	Simple programs for learning concepts based Pointers	16
		Total	96

References:

1. A Book on C by Al Kelley and Ira Pohl
2. Computer Science - A Structured Programming Approach using C by Behrouz Forouzan & Richard Gilberg.
3. The C Programming Language by Dennis Ritchie

Course:UMAT-606 (Software Lab-II)

Course Title : Data Structures & File Handling using C

Course Objectives:

Introduction to structures, File Handling & command line arguments,Introduction to Bitwise operators, Implementation of data Structures: Single linked list, Stacks, Queue, Binary Search Tree, Mini-Project based on C-concepts (optional)

Course Outcomes:

1. Understanding of how to use structures
2. Ablity to do simple file operations on text files.
3. To be able to implement single linked list operations.
4. To be able to implement stacks and queues using arrays as well as linked list.
5. To be able to implement binary search tree along with their traversals without deletion.
6. Basic understanding of bit-wise operators.

UMAT-606: **C Programming Lab-Part II; Credits:3**			
Unit	Topic	Contents	Periods
1	Advanced Pointers	Programs based onadvanced C Pointers	8
2	Structures	Understanding of structures.	16
3	File Handling	Simple file operations like open, close, read, write, append.	16
4	Single Linked Lists	Creation, Insertion, Deletion, Applications	16
5	Stacks, Queues	Stack using Linked List and arrays, Queues using Linked List and arrays	8
6	Trees	Binary search tree with Inorder, Preorder and postorder traversal.	8
7	Bitwise opeators	Understanding of bit-wise operators	8
8	Mini-project (optional)	Application based on c-concepts.	32
		Total	112

References:

1. Computer Science - A Structured Programming Approach using C by Behrouz Forouzan & Richard Gilberg.
2. The C Programming Language by Dennis Ritchie
3. Pointers in C by Yashwant Kanetkar
4. A Book on C by Al Kelley and Ira Pohl

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Computer Science Syllabus
for B.Sc.(Hons.) in Mathematics with three-subject combination as Mathematics, Computer Science and Statistics

Semester-I

Introduction to Information Systems

CODE: UCSC 101 **Credits: 3** **42 periods**

Unit I: An Introduction to Information Systems in Organizations (10 periods)
Information concepts – Computer based Information Systems – Business information systems – Systems development – Organizations and Information systems – Competitive advantage – Financial evaluation of Information Systems – Global Challenges in Information Systems

Unit II: Technology (15 periods)
Hardware components – Processing and Memory devices – Secondary storage & I/O devices – Computer System types – Data centers – Green Computing – Systems software – Data management – Data modeling and Database characteristics – Database management systems – Database applications.

Unit III: Information & Decision support systems (12 periods)
Decision making & Problem solving – An overview of Management Information systems – Functional aspects of the MIS – An overview of Decision Support Systems – Components of a decision support system – Group decision support systems.

Unit IV: Systems development (5 periods)
An overview of systems development – Traditional Systems Development life cycle – Alternate systems development life cycle – Tips to avoid project failure.

Total **42 periods**

Key Text(s): by Ralph M. Stair and George, Fundamentals of information systems, W. Reynolds. (8^{th} edition)
Coverage of key text: Chapters 1, 2, 3, 6, 8.

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Practicals: Introduction to Information Systems

CODE: UCSC 102 **Credits: 2** **56 periods**

Unit I: Introduction of Relational Databases

Unit II: Sequential Query Language (SQL) Fundamentals
Data Definition Language - Tables, Views, Schemas, Data population, Data level Security/authentication. Data Manipulation Language – Basic SQL structure, constraints, string functions, aggregate functions, joins. Query optimization (optional). Introduction of PL/SQL (optional)

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Semester-II
Problem Solving using Computers

CODE: UCSC 201 **Credits 3** **42 Periods**

Unit I Introduction 4 Periods

What Is Computer Science? What Is Programming? Data Structures and Abstract Data Types. Why Study Algorithms? Built-in Atomic Data Types, Built-in Collection Data Types, Input and Output, String Formatting, Control Structures

Unit II Analysis of algorithms 4 Periods

Complexity of algorithms, Big O notation, best case-worst case-average case complexity. Lists, Dictionaries

Unit III Basic Data Structures 5 Periods

Linear Structures, Stack Abstract Data Type, Infix, Prefix and Postfix Expressions. Conversion of Infix Expressions to Prefix and Postfix, General Infix-to-Postfix Conversion. Queue Abstract Data Type

Unit IV Recursion 5 periods

Definition, three laws of recursion, Examples for recursion, visualization of recursion.

Unit V Sorting and Searching 8 periods

The Sequential Search, Analysis of Sequential Search, The Binary Search, Analysis of Binary Search, Hashing, Hash Functions, Sorting: The Bubble Sort, The Selection Sort, The Insertion Sort, The Shell Sort, The Merge Sort, The Quick Sort.

Unit VI Trees and Tree Algorithms 8 periods

Examples of Trees, Parse Tree, Tree Traversals, Priority Queues with Binary Heaps, Binary Heap Operations

Unit VII Graphs and Graph Algorithms 8 periods

The Graph Abstract Data Type, Adjacency Matrix, Adjacency List, Breadth First Search, Breadth First Search Analysis, Depth First Search, Depth First Search Analysis.

Total **42 Periods**

Key Text(s): Brad Miller and David Ranum, Problem Solving with Algorithms and Data Structures using Python, Luther College
http://interactivepython.org/runestone/static/pythonds/index.html

Coverage of Key Text(s):Chapters: 1(1.1 to 1.10), 2, 3(3.1 to 3.14),4(4.1 to 4.10), 5,6(6.1 to 6.10), 7(7.1 to 7.16)

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Practicals: Python Lab

CODE : UCSC 202 **Credits: 2** **56 periods**

In this course Python language and object oriented concepts are learnt. Some of the algorithms are implemented from Problem Solving and Computing Course using python language.

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Semester-III

Data Visualization

CODE: UCSC 301 **3 Credits** **42 Periods**

Unit I	Introduction	**3 periods**
What is visualization and why do it?		
Unit II	Analysis	**10 periods**
What: Data abstraction		3 periods
Why: Task abstraction		4 periods
Analysis: Four levels for validation		3 periods
Unit III	Principles and rules	**7 periods**
Marks and channels		4 periods
Rules of thumb		3 periods
Unit IV	Data encoding: spatial and visual	**9 periods**
Arrange tables		3 periods
Arrange spatial data		3 periods
Map color and other channels		3 periods
Unit V	Views	**13 periods**
Manipulate view		3 periods
Facet into multiple views		4 periods
Reduce items and attributes		3 periods
Embed: Focus+context		3 periods
Total:		**42 periods**

Key text(s): Visualization Analysis & Design, Tamara Munzner, CRC Press, Taylor & Francis Group, 2015.
Coverage in key text: Chapters 1-8, 10-14

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Data Visualization Lab

CODE: UCSC 302 **2 Credits** **56 Periods**

KeyText(s): Data Visualization with R – 100 examples, Thomas Rahlf, Springer International, 2017.

Coverage from key text: Select examples from Ch 6-11

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Semester-IV

Artificial Intelligence

CODE: UCSC 401	**Credits: 3**	**42 Periods**
Unit I: Introduction		3 periods
Unit II: Propositional Logic		8 periods
Unit III: First order Predicate Logic		12 periods
Unit IV: Limitations of logic		3 periods
Unit V: Search, games and problem solving		16 periods
Total		**42 periods**

Key Text(s): Wolfgang Ertel, Introduction to Artificial Intelligence, Springer, 2011.
Coverage in Key text: Chapters 1-4, 6

Fundamentals of Linux/Unix Systems Lab

CODE: UCSC 402 **2 Credits** **56 Periods**

I. Introduction to Unix
   a. History, Philosophy
   b. Basic Unix commands and overview

II. Linux File System and Shell
   a. The File Management
      i. File utility commands like: ls, cp, mv, rm, touch, df, du, chmod, etc
      ii. File comparissions utilities: comm, cmp, diff
      iii. File Editors
      iv. emacs, etc
      v. cat, tail, head, more, less, etc
   b. File structure and hierarchy
      i. Linux environment file hierarchy (/,/etc,/dev, /home, /opt,…)
      ii. File permissions (owner, group, all others, read, write, execute)
      iii. File type (terminals, symbolic links, directories, etc)

III. User Administration
   a. adduser, passwd, usermod
   b. superuser, who

IV. Processes and Schedulers
   a. cron, at
   b. top, ps, wait, sleep
   c. kill,

V. Software Installation in Linux
   a. Synaptic, yum, apt-get

VI. Basic shell scripting
   a. Loops, grep, functions, variables

VII. Basic Linux networking
   a. Ping, netstat, ifconfig, route, traceroute, ssh, scp

VIII. Stream Editors (optional)
   a. sed, awk

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