SCHOOL OF ARCHITECTURE, SCIENCE AND TECHNOLOGY

YASHWANTRAO CHAVAN MAHARASHTRA OPEN UNIVERSITY

V130: M. Sc. (Mathematics) {2021 Pattern}

(Syllabus for Semester 01 to 04)

2021

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PROGRAMME ADVISORY COMMITTEE (PAC)

V130: M Sc (Mathematics) {2021 Pattern}	
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07	Prof. Dr Meenakshi P Wasadikar, Prof. HOD, Dr Babasaheb Ambedkar Marathwada University (M: 77450 84648, 083299 38772), Email: wasadikar@yahoo.com
08	Prof. Dr S R Chaudhari, Prof. HOD, North Maharashtra University, Jalgaon (M:094201 29704), Email: drsrchaudhari@nmu.ac.in

SYLLABUS OF ALL COURSES AT SEMESTER 01 AND 02 WERE FINALIZED IN PAC MEETING HELD ON 31 AUG 2018

SYLLABUS OF ALL COURSES AT SEMESTER 03 AND 04 WERE FINALIZED IN PAC MEETING HELD ON 14 SEPT 2019

- **First eBook Publication** : June 2021
- **Publisher** : Director, School of Architecture, Science and Technology, YCMOU, Nashik - 422 222, MH, India
- **Free Download from Website at:** http://www.ycmou.ac.in/ and http://ycmou.digitaluniversity.ac/
- **Send Your Feedback about this syllabus to:** director.ast@ycmou.ac.in

CONTENTS

About the Programme

Programme Code: V130

Programme Name: M.Sc (Mathematics)

This M Sc programme is uniquely designed to impart essential knowledge in all major areas of pure or applied mathematics. This programme offers an exciting opportunity for specialization in mathematics to model and solves different real-life problems. The course contents of total 04 semesters are a carefully selected blend of theory and practical which prepares students for specialist professional employment, research in academia, and industry for broader applications.

Objectives and Scope of the Programme

Objectives of the Programme:

This programme has the following broad objectives:

- To prepare the learners, understand and apply the basic as well as advanced principles of mathematics for solving problems from science with an emphasis on applications
- To produce the learners who are well-grounded in the fundamentals of Mathematics with the acquisition of the necessary skills, tools, and techniques required in many application areas
- To develop an ability to study the conceptual problem and critically analyze, and also promote the use of mathematics in industry and applied sciences
- To provide exposure and motivate students for research in current trends of mathematics

Scope of the Programme:

After successful completion of the M Sc programme, the learner has ample opportunities to use their mathematical knowledge in different areas:

- Career opportunities in government organizations like Defense Research and Development Organization (DRDO), Indian Space Research Organization (ISRO), research laboratories like Council of Scientific and Industrial Research or government-owned scientific organizations.
- Job positions like Mathematics Specialist, Quantitative Risk Analyst, Treasury Management Specialist, Public sector banking, Financial institutions, Engineering or Insurance Sectors, etc.
- Job opportunities in the teaching profession at science and engineering colleges, and Universities
- Scope for Higher Studies and find lucrative opportunities in the field of research.

Mode of Education

This Programme will be offered in Open and Distance Learning (ODL) Mode as defined in "UGC Open and Distance Learning Programmes and Online Programmes Regulations, 2020" published in the gazette notification by dated 4th Sept 2020 by the UGC as specified below.

> *"Open and Distance Learning Mode means a mode of providing flexible learning opportunities by overcoming separation of teacher and learner using a variety of media, including print, electronic, online and occasional interactive face-to-face meetings with the learners or Learner Support Services to deliver teaching-learning experiences, including practical or work experiences"*

BASIC INFORMATION

1. **Mode of Education**: ODL Mode.
2. **Minimum Programme Duration**: 2 years/ 4 semesters after B.Sc./B.A. or Equivalent pass with Maths
3. **Total Courses and Credit Points:** Total 5 Theory courses each of 4 credits at **each** semester. Total 20 courses of total 80 credit points at Semesters 01-04.
4. **Required Study Efforts**: Total 2400 Hours (including Self-Study) during all 4 semesters. 600 Hours (including Self-Study) during **each** semester.
5. **Medium of Instruction**: The programme is available only in English
6. **Profile of Prospective Students**: In-Service Science Teachers from Schools/ Junior College and Equivalent pass students
7. **Attendance**: Minimum **75 %** attendance recommended for all Theory type of courses.
8. **Total programme Fee: Total ₹ 24,000 for all 04 Semesters**
9. **Equivalence Status**: UGC and DEB recognized and approved [AY 2020-2021 and onwards] with UGC/DEB letter F.No. 1-2/2021 (DEB-I), Dated: 02.08.2021, available at https://www.ugc.ac.in/pdfnews/4204139_HEI-Recognition-list-02-08-2021.pdf

ELIGIBILITY AND FEES

Admission Eligibility	**Certification Eligibility**	**Fees and Deposit per year** UF is payable to university along with admission form at the start of each year.
Any BSc with Maths upto Second year/ BA with Maths/ BE/ BTech or equivalent pass	Min 40% or better marks in total 20 courses (subjects) of total 80 credit points at Semesters 01-04. Aggregate performance and Class in the programme shall be reported on the basis of **only** semesters 03-04.	**Desc** / **INR ₹** University Fee (UF) / **6,000** Study Center Fee (SCF) / **6,000** Additional Services Fee (ASF) / NA **Total ≈** / **12,000** **Refundable LD** (Payable only when student choose to avail Library Facility at the SC) / **1,500**

PROGRAMME STRUCTURE

V130:M.Sc.(Mathematics){2021 Pattern}					
Course → Sem↓	Course 01, 4 CR, T	Course 02, 4 CR, T	Course 03, 4 CR, T	Course 04, 4 CR, T	Course 05, 4 CR, T
Sem 01 20 CR	**S25011**: Real Analysis	**S25012**: Abstract Algebra	**S25013**: Ordinary Differential Equations	**S25014**: Topology	**S25015**: Numerical Analysis
Sem 02 20 CR	**S25021**: Measure and Integration Theory	**S25022**: Linear Algebra	**S25023**: Partial Differential Equations	**S25024**: Number Theory	**S25025**: Integral Transforms
Sem 03 20 CR	**S25031**: Complex Analysis	**S25032**: Field Theory	**S25033**: Integral Equations	**S25034**: Discrete Mathematics	**S25035**: Operations Research
Sem 04 20 CR	**S25041**: Differential Geometry	**S25042**: Functional Analysis	**S25043**: Classical Mechanics	**S25044**: Cryptography	**S25045**: Topics in Fuzzy Mathematics

Development Scheme:	Teaching-Learning Scheme:
• Minimum 24 Lectures for each course (01 – 05) @ 2 Lectures / Week shall be developed • Textbook in SLM format (**eBook)**: eBook in SLM format for each course (Free Download from University website) at all semester 01 to semester 04	• Minimum **24** Lectures for each course (01 – 05) @ 2 Lectures / Week, during each semester. • Minimum 12 Counselling Sessions each of 1 hr for each Theory Course shall be provided by the counsellors at the Study Center during each semester

SEMESTERS AND COURSES

SN	Code	Name	CA	EE	TM	Type	CR	Grade Point
Semester 01: 20 CRs, Specializations of M.Sc.								
01	S25011	Real Analysis	20	80	100	T	4	4
02	S25012	Abstract Algebra	20	80	100	T	4	4
03	S25013	Ordinary Differential Equations	20	80	100	T	4	4
04	S25014	Topology	20	80	100	T	4	4
05	S25015	Numerical Analysis	20	80	100	T	4	4
Semester 02: 20 CRs, Specializations of M.Sc.								
06	S25021	Measure and Integration Theory	20	80	100	T	4	4
07	S25022	Linear Algebra	20	80	100	T	4	4
08	S25023	Partial Differential Equations	20	80	100	T	4	4
09	S25024	Number Theory	20	80	100	T	4	4
10	S25025	Integral Transforms	20	80	100	T	4	4
Semester 03: 20 CRs, Specializations of M.Sc.								
11	S25031	Complex Analysis	20	80	100	T	4	4
12	S25032	Field Theory	20	80	100	T	4	4
13	S25033	Integral Equations	20	80	100	T	4	4
14	S25034	Discrete Mathematics	20	80	100	T	4	4
15	S25035	Operations Research	20	80	100	T	4	4
Semester 04: 20 CRs, Specializations of M.Sc.								
16	S25041	Differential Geometry	20	80	100	T	4	4
17	S25042	Functional Analysis	20	80	100	T	4	4
18	S25043	Classical Mechanics	20	80	100	T	4	4
19	S25044	Cryptography	20	80	100	T	4	4
20	S25045	Topics in Fuzzy Mathematics	20	80	100	T	4	4

GRADING SYSTEM

1. "**Absolute Grading**": the marks are converted to grades based on pre-determined class intervals.
2. "**Letter Grade**": It is an index of the performance of students in a said programme. Grades are denoted by letters O, A+, A, B+, B, C, P and F.
3. "**Grade Point**": It is a numerical weight allotted to each letter grade on a 10-point scale. Grade Point shall be "0 (Zero)" for Letter Grade "Ab" and "F". The marks scored by the examinee shall be converted into grade points by dividing the marks scored in the aggregate and dividing the resulting number by maximum marks, multiplying the result by ten, retaining the integer part (ignore the fractional part). Thus if a person has secured 56 marks out of 100 marks in aggregate for a course, we get (56/100) x 10 which is 5.6. Ignoring the fraction, we get 5 as the grade point.

Letter Grade	Grade Point	Class
O	10	Outstanding
A+	9	Excellent
A	8	Very Good
B+	7	Good
B	6	Above Average
C	5	Average
P	**4**	**Pass**
F	**0**	**Fail**
Ab	**0**	**Absent**

4. "**Credit Point**": It is the product of grade point and number of credits for a course.
5. "**Semester Grade Point Average (SGPA)**": It is a measure of performance of work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.
6. "**Cumulative Grade Point Average (CGPA)**": It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.
7. "**Transcript or Grade Card or Certificate**": Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester and CGPA earned till that semester.

EVALUATION PATTERN

SN	Type of Course	Continuous Assessment	End Examination
1	Theory (T)	"Continuous Assessment (**CA**)" of total **20** marks and total 4 SAQs, each of 5 marks, 1 SAQ on **each** CR in a **Single attempt only**	"End Examination (**EE**)" of total **80** Marks and **16** "Short Answer Questions (SAQs)" **each** of **05** marks (**4 out of 5 SAQs on each Credit**), during **150** Minutes. (**80%**)

1. **Separate and independent passing @ 40% in EE and (CAT+EE) shall be essential for Theory and Practical component of each course.** "CA, EE and Total marks" shall be separately reported for each course in the transcript or mark-statement.
2. **Only 1 attempt** for EE for **each** course shall be allowed in **each** semester. **Maximum 1 attempt**, for CAT for **each** course, shall be allowed in **each** semester.
3. **Only best of past performance shall be reported in transcript or mark statement**.
4. **Total student evaluation for**
    a. **Each** semester shall be for **500** marks.
    b. **Each** year shall be for **1000** marks
    c. **Each** regular PG degree shall be for **2000** marks.
5. **Reporting Semesters** for certification:
    - Min 40% or better marks in total 20 courses (subjects) of total 80 credit points at Semesters 01-04.
    - **Semester 03 and 04 Only** best of past performance shall be reported in the transcript or mark statement

SUCCESSFUL COMPLETION OF COURSE OR PROGRAMME

1. "Successful Completion of the Course" means - either course is exempted or student gets minimum specified or better grade, either in end examination of that course or by credit transfer. A student obtaining grade "F" shall be considered failed and will be required to reappear in the examination. The student obtained minimum "P" (Pass) letter grade required for successful completion of the each course.
2. "Successful Completion of the Programme" means – all courses at all semesters are successfully completed and the student obtained "P" (Pass) letter grade for all courses at all semesters along with minimum specified SGPA and CGPA.

SEMESTER 01

S25011: REAL ANALYSIS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25011	Real Analysis	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Comprehend the aspect of Metric Space which forms foundation for topology • Understand thorough foundation of Riemann integration theory • Use convergence of sequence and series of functions to evaluate Riemann integration of functions

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Metric Spaces** **Open and Closed Sets** **Sequences in Metric Spaces** **Continuity**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**Connected Metric Spaces** **Complete Metric Spaces** **Totally Bounded Subsets of Metric Spaces** **Compact Metric Spaces**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**Riemann Integral** **Necessary and Sufficient Conditions for Riemann Inegrability** **Properties of Riemann Integrals** **Mean Value Theorems and Fundamental Theorems of Calculus**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**Convergence and Uniform Convergence of Sequence of Functions** **Properties of functions preserved under uniform convergence** **Convergence and Uniform Convergence of Series of Functions** **Power series**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit [ebook: updated on 13 Oct 2020]	CR
1-1	**Metric Spaces**: Definition and examples of Metric spaces, Standard Metrics on $\mathbb{R}^n$, Discrete Metric Spaces, Open and Closed Balls	CR 01
1-2	**Open and Closed Sets**: Definition and examples of open and closed sets, unions and intersections open and closed sets, structure of open sets in $\mathbb{R}$, open and closed sets in subspaces.	
1-3	**Sequences in Metric Spaces:** Sequence and subsequence in Metric spaces, Convergence of sequence in metric spaces, Algebra of convergent sequences, Cauchy sequences and Bounded Sequences	
1-4	**Continuity**: Sequential Definition of continuity, Theorems of connected sets. Continuity in terms of open and closed sets, homeomorphism between two metric spaces, uniform continuity, examples.	
2-1	**Connected Metric Spaces**: Definition and examples of connected sets, equivalent characterization of connected sets, Connected subsets of $\mathbb{R}$, properties of continuous functions defined on connected metric spaces.	CR 02
2-2	**Complete Metric Spaces**: Definition and examples of complete sets, characterization of complete sets using limit point, relation between closed and complete spaces, theorems on complete sets.	
2-3	**Totally Bounded Subsets of Metric Spaces**: Definition and examples of connected sets, equivalent definitions of totally bounded sets, relation between bounded and totally bounded sets, totally bounded subsets of $\mathbb{R}$.	
2-4	**Compact Metric Spaces** Definition and examples of compact sets, equivalent characterization of compact sets, theorems on compact sets, properties of continuous functions defined on compact metric spaces.	
3-1	**Riemann Integral:** Concept of Lebesgue measure, sets of measure zero, lower and upper sum, defining Riemann Integral using upper and lower sums, numerical examples.	CR 03
3-2	**Necessary and Sufficient Conditions for Riemann Inegrability**: Various theorems on Necessary and Sufficient Conditions for Riemann Inerrability, examples of Riemann and non-Riemann integrable functions.	
3-3	**Properties of Riemann Integrals**: Algebra of Riemann integrable functions: addition, subtraction, scalar multiplication, absolute value etc., Inequalities on Riemann Integrals, Riemann integrals of non –negative functions, examples.	
3-4	**Mean Value Theorems and Fundamental Theorems of Calculus:** Definition of derivative of real valued functions of real variable, Rolle's theorem, Lagrange's Mean Value Theorem, Cauchy's Mean Value Theorem, First and Second Fundamental Theorems of Calculus	
4-1	**Convergence and Uniform Convergence of Sequence of Functions:** Pointwise convergence of sequence of functions, Uniform convergence of sequence of functions, Difference between pointwise and uniform convergence, examples.	CR 04
4-2	**Properties of functions preserved under uniform convergence:** Theorems on Continuity, Integrability and Differentiability of sequence of functions under uniform convergence, examples.	
4-3	**Convergence and Uniform Convergence of Series of Functions:** Pointwise convergence of series of functions, Uniform convergence of sequence of functions, Properties of functions preserved under uniform convergence of series of functions, Weierstrass M-Test for Uniform Convergence of series of functions, examples.	
4-4	**Power series**: Conditions for uniform convergence of power series, term by term differentiation and integration of power series, examples.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25011			
Text-Books			
S25011-T01			

Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25011 –RB1	Methods of Real Analysis Richard R. Goldberg	2nd ed Reprint 2017	9788120417571 Oxford & IBH Publishing Co. Pvt Ltd
S25011 –RB2	Principles of Mathematical Analysis, Rudin Walter	3rd, 1976,	Mc Graw HillInc.,USA
S25011 –RB3	Introduction to Real Analysis Bartle Robert G and Sherbert Donald R	2010	Wiley India Edition,
S25011 –RB4	Lectures on Advanced Real Analysis Karade T .M. and Salunke J N	2004	SonuNilu
S25011 –RB5	Real Analysis Royden H L	4th, 1993	Macmillan Co Inc, New York,
S25011 –RB6	Topology of Metric Spaces S Kumaresan	2nd 2011	9788184870589 Narosa Publishing House
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25011 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25011-WL1			

S25012: Abstract Algebra

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

Course Information

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25012	Abstract Algebra	4	12	120	20	80	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Built foundation of group and ring theory • Apply the concept of subgroup and normal subgroups to discuss the solvability of groups and thereby solvability of equations of any positive order • Generalize the concepts of divisibility to rings and apply them in general context and factorize polynomials.

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Direct product of groups** **Finitely generated abelian groups** **Normal Subgroups** **Homomorphisms of groups**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**Series of Groups** **Solvable groups** **Group action on a set** **Sylow Theory**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**Maximal and Prime ideals** **Ring of Polynomials** **Factorization of a polynomials over a field** **Factorization over Domains**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**Unique factorization Domains** **Principal ideal domains** **Euclidean Domains** **Ring of Gaussian Integers**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Direct product of groups:** (Preliminaries on groups, subgroups and cyclic groups) External direct product, Internal direct product and join of subgroups.	CR 01
1-2	**Finitely generated Abelian groups:** Generators and torsion group, finitely generated groups, Fundamental theorem for finitely greeted Abelian groups, Applications of fundamental theorem, decomposition of	

	groups.	
1-3	**Normal Subgroups:** Cosets, inner Automorphisms and normal groups, factor groups, Simple groups, Commutator subgroup.	
1-4	**Homomorphism of groups:** Isomorphism theorems, Maximal normal subgroups, Zassenhaus Lemma.	
2-1	**Series of Groups:** Subnormal and normal series of groups, composition series, Jordan-Holder theorem.	
2-2	**Solvable groups**: Solvable groups, Nilpotent groups, interrelation.	
2-3	**Group action on a set**: G-set, isometry subgroup, orbits, Applications of action of a group.	**CR 02**
2-4	**Sylow Theory:** Burnside theorem, p-groups, Cauchy's theorem, Sylow's theorems, Class Equation, Conjugate class, Application of Sylow's theorems to simple and abelian groups.	
3-1	**Maximal and Prime ideals:** (Preliminaries of rings, ideals and homomorphism) Fundamental theorem of ring homomorphisms, Maximal and Prime ideals, Prime fields.	
3-2	**Ring of Polynomials**: Polynomial in indeterminate, The Evaluation homomorphisms, Zeros of a polynomial.	
3-3	**Factorization of a polynomials over a field**: The division algorithm, irreducible polynomials, Eisenstein criterion, Unique factorization in $F[x]$.	**CR 03**
3-4	**Factorization over Domains**: Divisibility, Associates, units, irreducible elements, prime elements, ideals generated by prime element.	
4-1	**Unique Factorization Domains:** Factorization Domain, Unique factorization domain.	**CR 04**
4-2	**Principal ideal domains:** Principal ideal domain, Ascending chain conditions over PID, Prime elements and fundamental theorem of arithmetic's, primitive polynomials, Gauss lemma.	
4-3	**Euclidean Domains:** Euclidean valuation, Euclidean domain, Arithmetic's in Euclidean domain, Euclidean algorithm, Gaussian integers, multiplicative norms.	
4-4	**Ring of Gaussian Integers:** Euclidean algorithm, Gaussian integers, multiplicative norms.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25012			
Text-Books			
S25012-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25012 –RB1	A First Course in Abstract Algebra, J.B. Fraleigh	3rd 2002	Narosa Publishing House New Delhi.
S25012 –RB2	Topics in Algebra, Herstein I N	1975	Wiley Eastern Ltd. New Delhi,
S25012 –RB3	Basic Abstract Algebra, Bhattacharya P B, Jain S K and Nagpaul S.R.	2nd 1995	
S25012 –RB4	Abstract Algebra, Dummit David S and Foote Richard M	3rd	Wiley India Edition
S25012 –RB5	Contemporary Abstract Algebra, J.A. Gallian,		Narosa Publication
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25012 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25012-WL1			

S25013: Ordinary Differential Equations

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

Course Information

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25013	Ordinary Differential Equations	4	12	120	20	80	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Understand various methods of solutions of differential equations of first and second order. • Apply these methods to solve differential equations in physics and engineering fields • Discuss approximation and existence & uniqueness of solution of nth order differential equations to solve them using the techniques discussed thereby.

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Linear Equations with constant coefficients** **Dependence and independence of solutions** **Applications of Second Order Linear Equations** **The homogeneous equation of higher order**:	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**The non-homogeneous equation of higher order** **Linear Equations with variable Coefficients** **Reduction of the order** **Homogeneous equations with analytic coefficients**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**Linear Equations with Regular Singular Points** **Second order equations with regular singular points** **The Bessel equation** **Existence and Uniqueness of Solutions to First Order Equations**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**The method of successive approximations** **Non-local existence of solutions** **Existence and Uniqueness of Solutions to Systems and n-th Order Equations** **Complex n-dimensional space**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Linear Equations with Constant Coefficients:** Introduction, The second order homogeneous equation Initial value problems for second order equations, Uniqueness theorem	CR 01
1-2	**Dependence and independence of solutions:** Linear dependence and independence, A formula for the Wronskian, The non-homogeneous equation of order two.	
1-3	**Applications of Second Order Linear Equations:** Hooke's Law, Force acting upon the mass, Free, damped and undamped motion and Electric circuit problems	
1-4	**The homogeneous equation of higher order**: Initial value problems for n^{th} order equations, Existence and uniqueness theorems, Equations with real constants	
2-1	**The non-homogeneous equation of higher order:** A special method for solving the non-homogeneous equation, Algebra of constant coefficient operators.	CR 02
2-2	**Linear Equations with Variable Coefficients:** Introduction, Initial value problems for the homogeneous equation, Existence and uniqueness theorems, Solutions of the homogeneous equation.	
2-3	**Reduction of the order:** The Wronskian and linear independence, Reduction of the order of a homogeneous equation, The non-homogeneous equation.	
2-4	**Homogeneous equations with analytic coefficients**: Existence theorem for homogeneous equations with analytic coefficients, The Legendre equation, Power series method and problems.	
3-1	**Linear Equations with Regular Singular Points:** Introduction, The Euler equation, Second order equations with regular singular points.	CR 03
3-2	**Second order equations with regular singular points: T**he general ease, A convergence proof, The exceptional cases.	
3-3	**The Bessel equation:** The Bessel equation and their solutions of first and second kind, Regular singular points at infinity.	
3-4	**Existence and Uniqueness of Solutions to First Order Equations**: Introduction, Equations with variables separated, Exact equations.	
4-1	**The method of successive approximations**: The Lipschitz condition, Convergence of the successive approximations.	CR 04
4-2	**Non-local existence of solutions**: Approximations and uniqueness of solutions, Equations with complex-valued functions.	
4-3	**Existence and Uniqueness of Solutions to Systems and n-th Order Equations**: Introduction, An example central forces and planetary motion, Some special equations.	
4-4	**Complex n-dimensional space**: Systems as vector equations, Existence and uniqueness of solutions to systems, Local Existence, Nonlocal existence and approximation and uniqueness**,** Existence and uniqueness for linear systems: Equations of order n.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25013			
Text-Books			
S25013-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25013 –RB1	An Introduction to OrdinaryDifferentialEquations, Earl A.Coddington	2009	PHI Learning Private Limited, New Delhi
S25013 –RB2	Differential equations, Ross Shepley L. (for UN: 1-3)	3rd, 2007	Wiley – India,
S25013 –RB3	Ordinary differential equations,	3rd,	John Wiley and Sons,

	Birkhoff Garrett and Rota Gian - Carlo	1978	Third edition,
S25013 –RB4	Lectures on ordinary differential equations Karade T M	1995	Unpublished,
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25013 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25013-WL1			

S25014: TOPOLOGY

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25014	Topology	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Understand the basic concepts of topology and base for the topology • Discuss continuity of functions in topological spaces • Apply countability axioms for discussion of compactness, connectedness and sequential continuity of functions.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Topological spaces** **Basis and Subbasis for a topology** **Product and subspace topologies** **Limit points**	**CR 01** **MLs** **01-20**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
02-01 02-02 02-03 02-04	**Continuous functions** **Quotient spaces** **Connected spaces** **Locally connected spaces**	**CR 02** **MLs** **21-40**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
03-01 03-02 03-03 03-04	**Compact spaces** **Forms of compact spaces** **Countability axioms** **Lindelöf spaces**	**CR 03** **MLs** **41-60**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
04-01 04-02 04-03 04-04	**Separation axioms** **Regular and normal spaces** **Urysohn lemma** **Compactification**	**CR 04** **MLs** **61-80**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Topological spaces:** Definition and examples of topological space,	CR 01
	Basis and Subbasis for a topology: Basis for a topology, finer and coarser topological spaces, subbasis	
1-2	**Product and subspace topologies**: Order topology, Product topology on $X \times Y$, Subspace topology	
1-3	**Limit points**: closed sets and limit points, closure and Interior, Hausdörff spaces	
2-1	**Continuous functions**: Continuity of a function, Homeomorphism, Pasting lemma,	CR 02
2-2	**Quotient spaces**: Product topology, Metric topology, Quotient topology	
2-3	**Connected spaces**: separations, Connected sets, cartesian product of connected sets,	
2-4	**Locally connected spaces**: components and path components, locally connected sets.	
3-1	**Compact spaces:** Compact sets, Hausdörff spaces and Compact sets, continuity and connected sets, Finite intersection property.	CR 03
3-2	**Forms of compact spaces:** Limit point compact sets, sequentially compact sets, countably compact sets, locally compact sets.	
3.3	**Countability axioms**: First countable axiom, second countable axiom, dense sets.	
3.4	**Lindelöf spaces:** Separable space, Lindelöf space.	
4-1	**Separation axioms**: T_0, T_1, T_2 spaces	CR 04
4-2	**Regular and normal spaces**: T_3, $T_{3\frac{1}{2}}$ spaces, regular spaces and Normal spaces	
4-3	**Urysohn lemma**: Urysohn's lemma, Tiesz extension theorem.	
4-4	**Compactification**: Completely regular spaces, Stone-Cech compactification.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25014			
Text-Books			
S25014-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25014 –RB1	Topology: First course, J R Munkres		Prentice Hall Inc., New Jersey
S25014 –RB2	Theory and Problems of Set Theory and Related Topics, Lipshutz Seymour		Schaum Publishing Co. New York
S25014 –RB3	Foundations of General Topology, Pervin William J		Academic Press
S25014 –RB4			
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25014 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25014-WL1			

S25015: NUMERICAL ANALYSIS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem.	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25015	Numerical Analysis	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Find solutions of algebraic or transcendental equations using an appropriate numerical method • Solve linear systems of equations using an appropriate numerical method • Apply the techniques of numerical methods to solve ordinary differential equations.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Errors in Numerical Calculations** **Solutions of algebraic and transcendental equations** **Newton Raphson method** **Interpolation**	**CR 01** **MLs** **01-20**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
02-01 02-02 02-03 02-04	**Matrix Theory** **Systems of Linear Algebraic equations** **Direct methods** **Iteration methods**	**CR 02** **MLs** **21-40**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
03-01 03-02 03-03 03-04	**Numerical solutions of ordinary differential equations** **Successive approximation** **Euler's method** **Runge-Kutta method**	**CR 03** **MLs** **41-60**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
04-01 04-02 04-03 04-04	**Numerical Differentiation and integration** **Methods based on Finite Differences** **Composite Integration methods** **Interpolation and approximation**	**CR 04** **MLs** **61-80**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit [ebook: updated on 1 Oct 2020]	CR
1-1	**Errors in Numerical Calculations:** Approximate numbers and significant digits, rounding off numbers, absolute, relative and percentage errors.	CR 01
1-2	**Solutions of algebraic and transcendental equations:** Introduction, Bisection method, Iteration method, method of false position.	
1-3	**Newton Raphson method:** Newton Raphson method, generalized Newton's method.	
1-4	**Interpolation:** Finite differences- forward differences, backward differences, Newton's forward difference formula, Newton's backward difference formula.	
2-1	**Matrices:** Basic Definitions, Inverse of a matrix, rank of a matrix.	CR 02
2-2	**Systems of Linear Algebraic equations:** Introduction, linear systems of Equations, consistency of linear systems of Equations.	
2-3	**Solutions of Linear Systems:** Direct methods-Matrix inversion methods, Gauss Elimination method, Gauss - Jordan Elimination method, Triangularization method.	
2-4	**Iterative methods:** Jacobi iteration method, Gauss Seidal iteration method	
3-1	**Numerical solutions of ordinary differential equations:** Introduction, Initial Value Problem, Boundary value problem.	CR 03
3-2	**Solutions:** Single step methods, Solution by Taylor series	
3-3	**Euler's method:** Euler's method, modified Euler's method	
3-4	**Runge-Kutta method:** Runge-Kutta method, Picards method of successive approximation	
4-1	**Numerical Differentiation and integration:** Introduction, Numerical Differentiation, Numerical Integration, Methods based on interpolation	CR 04
4-2	**Methods based on Finite Differences:** Trapezoidal rule, Simpson's 1/3 rule, Simpson's 3/8 rule	
4-3	**Composite Integration methods:** Gauss quadrature methods, Gauss-Legendre Integration methods, Gauss-Legendre Formulas.	
4-4	**Interpolation and approximation:** Introduction, Langrange Finite difference operators, Hermite interpolation.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25015			
Text-Books			
S25015-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25015 –RB1	Introductory methods of Numerical Analysis, S. S. Sastry	4th	Prentice Hall
S25015 –RB2	Numerical methods for scientific and engineering computation. Jain, Iyengar and Jain	4th Edition	New Age Publication, New Delhi
S25015 –RB3	Numerical method & Analysis, J. I. buchaman and P. R. Turner		Prentice Hall
S25015 –RB4			
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25015 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25015-WL1			

SEMESTER 02

S25021: MEASURE AND INTEGRATION THEORY

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25021	Measure and Integration Theory	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Develop fundamentals of measurable sets and functions • Apply the concept of measurability of function and sets to solve integration of functions. • Discuss L^p spaces in more general setting and use them to prove Riesz theorem.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Lebesgue Measure** **The σ-Algebra of Lebesgue Measurable Sets** **Approximate measurable sets** **Additivity of measurable sets**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**Measurable Functions** **Algebra of measurable functions** **Sequential Pointwise Limits and Simple Approximation** **Littlewood's Three Principles**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**Integration of Bounded Measurable Functions** **General Lebesgue Integration** **Countable Additivity and Continuity of Integration** **Lebesgue Integration Further Topics**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**Differentiation and Integration** **Functions of Bounded Variations** **The L^p Spaces** **The Riesz Theorem**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Lebesgue Measure:** measure, Lebesgue Outer Measure, Measurable sets.	CR 01
1-2	**The σ-Algebra of Lebesgue Measurable Sets:** Union, intersection, complementation of measurable sets, countable union of measurable sets, measurability of intervals.	
1-3	**Approximate measurable sets**: Outer and Inner Approximation of Lebesgue Measurable Sets.	
1-4	**Additivity of measurable sets:** Countable Additivity, Continuity of measure, The Borel-Cantelli Lemma, Non-measurable sets, The Cantor Set and the Cantor-Lebesgue.	
2-1	**Measurable Functions**: Measurability of function, equivalent conditions for measurability.	CR 02
2-2	**Algebra of measurable functions:** Sums, Products, and Composition of measurable functions.	
2.3	**Sequential Pointwise Limits and Simple Approximation:** Theorems on sequential limits.	
2.4	**Littlewood's Three Principles:** Three principles, Egoroffs Theorem, and Lusin's Theorem.	
3-1	**Integration of Bounded Measurable Functions:** The Riemann Integral, The Lebesgue Integral of a Bounded Measurable Function over a Set of Finite Measure, Linearity and Monotonicity of Integration, The Bounded Convergence Theorem.	CR 03
3-2	**General Lebesgue Integration:** The Lebesgue Integral of a Measurable Nonnegative Function, The Monotone Convergence Theorem, The General Lebesgue Integral, The Lebesgue Dominated Convergence Theorem.	
3.3	**Countable Additivity and Continuity of Integration:** The Vitali Convergence theorem, uniformly integrable functions,	
3.4	**Lebesgue Integration Further Topics:** Uniform Integrability, General Vitali Convergence Theorem, Convergence in Measure, Characterizations of Riemann and Lebesgue Integrability, Lebesgue Theorem.	
4-1	**Differentiation and Integration:** Continuity of Monotone Functions, Differentiability of Monotone Functions: Lebesgue's Theorem	CR 04
4-2	**Functions of Bounded Variations:** Bounded and total variations, Jordan Decomposition, Continuous Functions	
4-3	**The L^p Spaces:** Normed Linear Spaces, The Inequalities of Young, Holder, and Minkowski's inequality.	
4-4	**Riesz Theorem**: Banach Space, Riesz-Fisher theorem, Approximation and Separability, The Riesz Representation Theorem.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25021			
Text-Books			
S25021-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25021 –RB1	Real Analysis, H. L. Royden and P. M. Fitzpatrick	4th, 2010	Pearson Education Asia China Machine press.
S25021 –RB2	Real Analysis, H. L. Royden	2nd , 1968	The MacMillan Company New York
S25021 –RB3	Lebesgue Measure and Integration, P.K. Jain and V. P. Gupta	1986	John Willey and Sons, New York
S25021 –RB4			
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25021 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25021-WL1			

S25022: LINEAR ALGEBRA

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25022	Linear Algebra	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Develop concepts of vector spaces and modules • Solve problems based on Linear transformations and Characteristic roots • Construct matrices in Nilpotent, Jordan and Rational forms which are useful for solving system of equations • Discuss adjoint, self-adjoint and normal linear trans formations

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Vector Spaces** **Dual spaces** **Inner product spaces** **Modules**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**Linear transformations** **Characteristic roots** **Matrices** **Triangular forms**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**Nilpotent forms** **Jordan form** **Rational Canonical form** **Trace and transpose of a matrix**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**Determinants** **Operators** **Normal operator** **Real Quadratic forms**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Vector Spaces: (**Preliminaries on vector spaces, Linear independence and base)Direct product of subspaces, Homomorphism, Isomorphism theorems,	CR 01
1-2	**Dual Spaces**: Theorems related to Hom(V, W), Dual space of a vector space, Annihilator.	
1-3	**Inner product spaces:** Inner product, Gram-Schmidt normalization process	
1-4	**Modules:** Submodules, fundamental theorem of finitely generated modules over Euclidean rings, homomorphisms, irreducible modules.	
2-1	**Linear transformations:** Algebra of Linear transformations, Minimal polynomial of a Linear Transformation, Invertible Linear transformation. Rank of linear transformation.	CR 02
2-2	**Characteristic roots:** Idempotent, nilpotent linear transformations, characteristic roots.	
2-3	**Matrices:** Matrix of a Linear Transformation, Relation between algebras of $n \times n$ matrices and set of matrices related to linear transformations.	
2-4	**Triangular form:** Triangular form of a linear transformation, invariant subspaces, Theorems on triangular form.	
3-1	**Nilpotent forms:** Theorems related nilpotent linear transformation, Invariants of a linear transformation, cyclic subspace under Linear transformation,	CR 03
3-2	**Jordan form:** Jordan block, Jordan form diagonalizable matrix.	
3-3	**Rational Canonical form:** Companion matrix of a polynomial, rational canonical form of a linear transformation, elementary divisors of a linear transformation.	
3-4	**Trace and transpose of a matrix:** trace, transpose, symmetric matrix, skew symmetric matrix, adjoint.	
4-1	**Determinants:** Determinants of a matrix, properties of determinant, characteristic polynomials and roots.	CR 04
4-2	**Operators:** Hermitian, Unitary transformations and their properties. Operators and Their Matrices.	
4-3	**Normal operator:** Adjoint and normal operator. Properties of Normal operator, Its relationship with unitary and Hermite transformation, Orthogonal Projections and the Spectral Theorem.	
4-4	**Real Quadratic forms:** Bilinear and Quadratic Forms.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25022			
Text-Books			
S25022-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25022 –RB1	Topics in Algebra, Herstein I N	1975	Wiley Eastern Ltd. New Delhi,
S25022 –RB2			
S25022 –RB3			
S25022 –RB4			
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25022 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25022-WL1			

S25023: Partial Differential Equations

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

Course Information

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25023	Partial Differential Equations	4	12	120	20	80	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Understand concepts, method of Solutions and applications of Partial Differential equations. • Improve problem solving and logical thinking abilities related to solution of partial differential equations • Use the concepts of Differential equations to solve wave and diffusion equations

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Ordinary Differential Equations** **Orthogonal Trajectories** **Partial Differential Equations of the First Order** **Cauchy's Problem for First -order Equations**	**CR 01** **MLs** **01-20**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
02-01 02-02 02-03 02-04	**Nonlinear Partial Differential Equations of the First Order** **Jacobi's Method** **Partial differential equations of the second order** **Linear Partial Differential Equations with Constant Coefficients**	**CR 02** **MLs** **21-40**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
03-01 03-02 03-03 03-04	**Equations with Variable Coefficients** **Nonlinear equations of the second order** **Laplace's Equation** **Separation of Variables**	**CR 03** **MLs** **41-60**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
04-01 04-02 04-03 04-04	**The Wave Equation** **Methods of Solution for Wave Equations** **The Diffusion Equation** **Methods of Solution for Diffusion Equation**	**CR 04** **MLs** **61-80**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit (Application Oriented problems)	CR
1-1	**Ordinary Differential Equations**: Surfaces and Curves in Three Dimensions, Simultaneous Differential Equations of the First Order and the First Degree in Three Variables, Methods of Solution of $\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}$.	CR 01
1-2	**Orthogonal Trajectories:** Orthogonal Trajectories of a System of Curves on a Surface, Pfaffian Differential Forms and Equations, Solution of Pfaffian Differential Equations in Three Variables.	
1-3	**Partial Differential Equations of the First Order:** PDEs, Origins of First -order Partial Differential Equations, Linear Equations of the First Order.	
1-4	**Cauchy's Problem for First -order Equations:** Integral Surfaces Passing through a Given Curve, Surfaces Orthogonal to a Given System of Surfaces.	
2-1	**Nonlinear Partial Differential Equations of the First Order**: Cauchy's Method of Characteristics, Compatible Systems of First-order Equations, Charpit's Method, Special Types of First-order Equations, Solutions Satisfying Given Conditions.	CR 02
2-2	**Jacobi's Method**: Jacobi's Method for Nonlinear Partial Differential Equations of the First Order, Applications of First -order Equations.	
2-3	**Partial differential equations of the second order:** The Origin of Second-order Equations, Second -order Equations in Physics, Higher -order Equations in Physics.	
2-4	**Linear Partial Differential Equations with Constant Coefficients**: Theorems on Equations with Constant Coefficients.	
3-1	**Equations with Variable Coefficients:** Reduction to various canonical forms, Characteristic Curves of Second -order Equations, Separation of Variables	CR 03
3-2	**Nonlinear equations of the second order**: Introduction, Monge's Method for Nonlinear equations of the second order.	
3-3	**Laplace's Equation:** The Occurrence of Laplace's Equation in Physics, Elementary Solutions of Laplace's Equation, Families of Equipotential Surfaces.	
3-4	**Separation of Variables**: Boundary Value Problems, Separation of Variables.	
4-1	**The Wave Equation:** The Occurrence of the Wave Equation in Physics, Elementary Solutions of the One -dimensional Wave Equation.	CR 04
4-2	**Methods of Solution for Wave Equations**: The Riemann- Volterra Solution of the One -dimensional Wave Equation, Vibrating Membranes, Application of the Calculus of Variations, Three -dimensional Problems, General Solutions of the Wave Equation.	
4-3	**The Diffusion Equation:** The occurrence of the diffusion equation in physics, The Resolution of Boundary Value Problems for the Diffusion Equation.	
4-4	**Methods of Solution for Diffusion Equation:** Elementary solutions of the diffusion equation, Separation of variables.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25023			
Text-Books			
S25023-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25023 –RB1	Elements of PartialDifferentialEquations, Ian N. Sneddon	1957	McGraw-Hill International Edition, New Delhi
S25023 –RB2	An Elementary Course in PartialDifferentialEquations, T. Amaranath	2nd 2003	Narosa Publishing House Pvt. Ltd, New Delhi

S25023 –RB3			
S25023 –RB4			
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25023 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25023-WL1			

S25024: NUMBER THEORY

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25024	Number Theory	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Understand the concept of arithmetical functions • Solve problems based on congruences and quadratic residues • know the concepts of primitive root theory

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**The Fundamental Theorem of Arithmetic** **The Euclidean Algorithm** **Arithmetic Functions μ and ϕ** **Arithmetic Functions and Dirichlet Product**	**CR 01** **MLs** **01-20**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
02-01 02-02 02-03 02-04	**Arithmetic Functions λ and σ_α** **Formal power series** **Congruences** **Polynomial Congruences**	**CR 02** **MLs** **21-40**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
03-01 03-02 03-03 03-04	**The Chinese Remainder Theorem** **Diophantine Equations** **Quadratic Residues** **Quadratic Reciprocity law**	**CR 03** **MLs** **41-60**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
04-01 04-02 04-03 04-04	**Jacobi Symbol** **Primitive roots** **Existence of Primitive Roots** **Indices**	**CR 04** **MLs** **61-80**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit **[eBook- updated on 1 Oct 2020]**	CR
1-1	**The Fundamental Theorem of Arithmetic**: Divisibility, Greatest common divisor, Prime numbers, The fundamental theorem of arithmetic.	**CR 01**
1-2	**The Euclidean Algorithm**: The series of reciprocals of the primes, The Euclidean algorithm, The greatest common divisor of more than two numbers.	
1-3	**Arithmetic Functions μ and ϕ**: The Mobius function $\mu(n)$,The Euler totient function $\phi(n)$, A relation connecting $\mu(n)$and $\phi(n)$, A product formula for $\phi(n)$.	
1-4	**Arithmetic Functions and Dirichlet Product:** The Dirichlet product of arithmetical functions, Dirichlet	

	inverses and the Mobius inversion formula, The Mangoldt function $\Lambda(n)$, Multiplicative functions, Multiplicative functions and Dirichlet multiplication, The inverse of a completely multiplicative function.	
2-1	**Arithmetic Functions λ and σ_α:** Liouville's function $\lambda(n)$, The divisor functions $\sigma_\alpha(n)$, Generalized convolutions.	**CR 02**
2-2	**Formal power series:** The Bell series of an arithmetical function, Bell series and Dirichlet multiplication, Derivatives of arithmetical functions, The Selberg identity.	
2-3	**Congruences:** Definition and basic properties of congruences, Residue classes and complete residue systems, Linear congruences.	
2-4	**Polynomial Congruences:** Reduced residue systems and the Euler-Fermat theorem, Polynomial congruences module p. Lagrange's theorem, Applications of Lagrange's theorem.	
3-1	**The Chinese remainder theorem**: Simultaneous linear congruences, Applications of the Chinese remainder theorem, Polynomial congruences with prime power moduli.	**CR 03**
3-2	**Diophantine Equations:** Diophantine equations, Finite continued fractions, Solutions of Diophantine equations by using finite simple continued fractions.	
3-3	**Quadratic Residues:** Quadratic residues, Legendre's symbol and its properties, Evaluation of $(-1/p)$ and $(2/p)$,	
3-4	**Quadratic Reciprocity law:** Gauss' lemma, The quadratic reciprocity law, Applications of the reciprocity law.	
4-1	**Jacobi Symbol**: The Jacobi symbol, Applications to Diophantine equations.	**CR 04**
4-2	**Primitive roots:** The exponent of a number $mod\ m$. Primitive roots and reduced residue systems, The nonexistence of primitive roots mod 2^α for $\alpha \geq 3$, The existence of primitive roots $mod\ p$ for odd primes p.	
4-3	**Existence of Primitive Roots**: Primitive roots and quadratic residues, The existence of primitive roots p^α , The existence of primitive roots $mod\ 2p^\alpha$, The nonexistence of primitive roots in the remaining cases, The number of primitive roots $mod\ m$.	
4-4	**Indices:** The index calculus	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25024			
Text-Books			
S25024-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25024 –RB1	Introduction to Analytic Number Theory, Tom M. Apostol	1976	Springer-Verlag NY Heidelberg Berlin
S25024 –RB2	Elementary Number Theory, Burton D M	2nd, 2003	Universal Book Stall, New Delhi
S25024 –RB3	Elementary Theory of Numbers, Hsiung C Y,	1992	Allied Publishers Ltd
S25024 –RB4	Elementary Number Theory, Jones Gareth A and Jones J Mary	2005	Springer,
S25024 –RB5	Elementary Number Theory, Karade T M, J N Salunke and Bendre M S,	2018	Sonu-Nilu
S25024 –RB6	Elementary Number theory with Applications, Koshy Thomas,	2002	Academic Press
S25024 –RB7	An Introduction to the Theory of Numbers, Niven I, Zuckerman H S and Montgomery H L	5th, 2004	Wiley Student Edition

S25024 –RB8	Elementary Number Theory and its Applications, Rosen K H	1986	Addison-Wesley
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25024 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25024-WL1			

S25025: INTEGRAL TRANSFORMS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25025	Integral Transforms	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Develop adequate knowledge of fundamentals of Fourier Integrals, Fourier Transforms, Inverse Fourier Transforms • Solve problems on differential and integral equations using Laplace, Fourier and Z transforms techniques • Solve problems based on Mellin Transform and Hankel transform techniques

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Fourier Integrals** **Fourier Transforms** **Inverse Fourier Transforms** **Applications of Fourier Transforms**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**Laplace Transform** **Properties of Laplace Transform** **The inverse Laplace Transform** **Applications of Laplace Transform**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**The Mellin Transform** **Inverse Mellin Transform** **Applications of Mellin transform** **The Henkel Transform**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**Applications of Hankel transform** **Finite transforms** **Z- Transforms** **Inverse Z-transform**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Fourier Integrals:** Preliminaries of Special Functions such as the Gamma, Error and Bessel functions, Fourier Integral Representations, Proof of the Fourier Integral Theorem.	CR 01
1-2	**Fourier Transforms**: Fourier Transform Pairs, Properties of the Fourier Transform, Fourier Cosine and Sine Transforms, Transforms of More Complicated Functions.	
1-3	**Inverse Fourier Transforms**: Inverse Fourier Transform, Inverse Fourier Sine Transform, Inverse Fourier Cosine Transform, Modulation Theorem, Convolution Theorem.	
1-4	**Applications of Fourier Transforms**: Boundary Value Problems, Heat Conduction in Solids, Mechanical Vibrations, Potential Theory.	
2-1	**Laplace Transform**: Introduction, The Transforms of Some Typical Functions.	CR 02
2-2	**Properties of Laplace Transform**: Basic properties**,** Transforms of More Complicated Functions.	
2-3	**The inverse Laplace Transform**: Properties of Inverse Laplace Transform, Partial fractions, Series method, Convolution theorem, Complex Inversion Formula.	
2-4	**Applications of Laplace Transform:** Evaluating Integrals, Solutions of ODEs, Solutions of PDEs, Solutions of Linear Integral Equations.	
3-1	**The Mellin Transform**: Evaluation of Mellin Transforms, Operational properties.	CR 03
3-2	**Inverse Mellin Transform:** Complex Variable Method, Inverse Transforms, Convolution theorem, Transforms in Polar coordinates.	
3-3	**Applications of Mellin transform:** Summation of series, Products of random variables, Distribution of potential in a wedge.	
3-4	**The Henkel Transform**: Introduction, Evaluation of Henkel Transforms, Operational properties.	
4-1	**Applications of Hankel transform:** Convolution theorem, Potential problems, Variation problems.	CR 04
4-2	**Finite Transforms**: Finite Fourier Transform: Finite Sine and cosine Fourier Transforms, Applications.	
4-3	**Z- Transform**: Evaluation of Z-Transforms, Operational properties.	
4-4	**Inverse Z-transform:** Inverse Z-transforms and their properties, Convolution theorem, Solutions of Difference Equations.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25025			
Text-Books			
S25025-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25025 –RB1	Integral Transforms for Engineers L. C. Andrews, B. K. Shivamoggi	2004	Prentice Hall of India Pvt. Ltd., New Delhi
S25025 –RB2	Fourier Transforms, Sneddon I N	1951	McGraw Hill
S25025 –RB3	Fourier Transforms and Its Applications, Bracemell	3rd, 1999	McGraw-Hill
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25025 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25025-WL1			

SEMESTER 03

S25031: COMPLEX ANALYSIS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25031	Complex Analysis	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Develop the concepts of analytic functions, harmonic functions and the importance of the Cauchy Riemann equations. • Apply analyticity solve integration of functions • Describe the basic properties of singularities, zeros residues, poles to solve integrals. • Apply concept of Hadamard Theorem and Uniqueness of Direct Analytic Continuation along a Curve, Power Series Method of Analytic Continuation

UNITS

UN	Name of the Unit (Modified by PAC)	CSs	Questions
01-01 01-02 01-03 01-04	**Power Series** **Analytic Functions** **Harmonic Functions** **Mobius Transformations**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**Power Series Representation of Analytic Functions** **Zeros of an Analytic Function** **The Index of a Closed Curve** **Morera's Theorem and Counting Zeros**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**Goursat's Theorem** **Classification of Singularities** **Residues** **The Argument Principle**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**Branches** **Hadamard Theorem** **Spaces** **Analytic Continuation**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Power Series**: Definition of power series, convergence, absolute convergence, Radius of convergence.	CR 01
1-2	**Analytic Functions**: Definition, Properties of analytic function, Periodic function, Branch of the logarithm, C-R equations, Harmonic conjugate.	
1-3	**Harmonic Function:** Definition, properties, Harmonic conjugate.	
1-4	**Mobius Transformations**: Mobius transformations, Path, Properties of path, Cross ratio, Orientation Principle.	
2-1	**Power Series Representation of Analytic Functions**: Leibniz's rule, Cauchy's Integral formula, Taylor's theorem, Cauchy's Estimate.	
2-2	**Zeros of an Analytic Function**: Zero of analytic function, Entire function, Liouville's theorem, Fundamental Theorem of Algebra, Identity theorem, Maximum Modulus theorem.	
2-3	**The Index of a Closed Curve and Cauchy's Theorem and Integral Formula**: Winding number, Cauchy's Integral Formula, Cauchy's theorem	
2-4	**Morera's Theorem and Counting Zeros**: Morera's Theorem**,** Counting zeros, The open mapping theorem.	
3-1	**Goursat's Theorem**: Goursat's theorem, The Maximum Principle, Schwarz's Lemma	CR 03
3-2	**Classification of Singularities**: Isolated singularity, removable singularity, pole, Laurent Series Development, Casorati-Weierstrass Theorem	
3-3	**Residues**: Residue Theorem, Contour integrations	
3-4	**The Argument Principle**: Meromorphic function, holomorphic function, Rouche's Theorem	
4-1	**Branches:** Branches of many valued Functions (Specially argz, logz, z^{alpha})	CR 04
4-2	**Hadamard Theorem**: Hadamard's three Circle Theorem, Phragmen-Lindelof theorem	
4-3	**Spaces** : Spaces and Continuous Functions, Spaces of Analytic functions, Hurmitz Theorem	
4-4	**Analytic Continuation**: Analytic Continuation, Uniqueness of Direct Analytic Continuation, Uniqueness of Direct Analytic Continuation along a Curve, Power Series Method of Analytic Continuation	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25031			
Text-Books			
S25031-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25031 –RB1	Functions of one Complex Variable, John B. Conway	2002	81-85015-37-6 Narosa Publishing House
S25031 –RB2	Complex Variables with Applications, Saminathan Ponnusamy, Herb Silverman	2006	10: 0-8176-4457-1 Birkhauser Boston
S25031 –RB3	Complex Analysis, Theodore W. Gamelin	2003	978-0387950693 Springer
S25031 –RB4	Complex Variables and Applications, R V Churchill and J W Brown	8th Ed	MC Graw Hill
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25031 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25031-WL1			

S25032: Field Theory

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

Course Information

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25032	Field Theory	4	12	120	20	80	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Understand concepts in field theory such as finite and algebraic extensions, algebraic elements, constructible elements, solvable groups etc • Aware the motive behind development of galois theory and solvability by radicals • Apply concepts in field theory for solving polynomial equations, systems of equations, ancient problems on impossibility of constructions and finding formula for solutions of polynomial equations. • Elaborate notions in finite field theory and their applications.

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Irreducible Polynomials** **Adjunction of Roots** **Algebraic Extensions** **Algebraically Closed Fields**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**Splitting Fields** **Normal Extensions** **Finite Fields** **Separable Extensions**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**Automorphism Groups** **Fixed Fields** **Fundamental Theorem of Galois Theory** **Different Galois Groups**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**Cyclotomic Polynomials** **Cylic Extensions** **Polynomials Solvable by Radicals** **Ruler and Compass Constructions**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Irreducible Polynomials**: Definition and properties of irreducible polynomials, Gauss Lemma, Eisenstein criterion with examples.	CR 01
1-2	**Adjunction of Roots**: Field extension, dimension, finite extension, embedding of a field, theorems and examples	
1-3	**Algebraic Extension**: Algebraic element, minimal polynomial, algebraic but not finite extension, finitely generated extension and their properties.	
1-4	**Algebraically Closed Fields:** Definition and equivalent forms of algebraically closed field, algebraic closure, and existence of algebraically closed field.	
2-1	**Splitting Fields:** Definitions and examples of splitting fields, uniqueness of splitting fields, degree of the extension of the splitting field with solved examples.	CR 02
2-2	**Normal Extensions:** Splitting field of family of polynomials, definition and equivalent forms of normal extension, Examples of normal extension.	
2-3	**Finite Fields:** multiple roots, prime field, characteristic of a finite field, isomorphism of finite fields, existence of finite fields of power prime order.	
2-4	**Separable Extensions:** Separable polynomial, separable extension, perfect field, simple extension and their properties, transitivity of finite separable extensions.	
3-1	**Automorphism Groups:** Definition of group of automorphism with examples, Dedekind lemma.	CR 03
3-2	**Fixed Fields:** Definition and properties of fixed fields, relation between normal extension and fixed fields, some examples.	
3-3	**Fundamental Theorem of Galois Theory:** Galois group, Galois extension, fundamental theorem of Galois theory and its applications	
3-4	**Different Galois Groups:** Galois group of a polynomial with distinct roots, Galois group of a polynomial of order 2 and 3, Examples of polynomials whose Galois groups are octic group, group of symmetries of the triangle.	
4-1	**Cyclotomic Polynomials:** Roots of unity, Cyclotomic polynomials, Galois group of Cyclotomic polynomials.	CR 04
4-2	**Cylic Extensions:** Definition and examples of cyclic extensions, special case of Hilbert's problem 90, relation between finite cyclic extension and splitting field.	
4-3	**Polynomials Solvable by Radicals:** Radical extension, polynomial solvable by radicals and its properties, Examples of polynomials solvable by radicals.	
4-4	**Ruler and Compass Constructions:** Constructible points, lines and circles, properties of constructible numbers, classical problems : problem of squaring a circle, duplicating a cube, trisecting an angle, constructing of a regular n-gon.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25032			
Text-Books			
S25032-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25032 –RB1	Basic Abstract Algebra, P.B. Bhattacharya, S.K. Jain, S.R. Nagpaul,	2nd Edition	Cambridge University Press
S25032 –RB2	Abstract Algebra, D.S. Dummit and R. M. Foote,	2nd Edition	John Wiley, 2002.
S25032 –RB3	Galois Theory, Joseph Rotman	2nd Edition	Springer International Edition

S25032 –RB4	Basic Algebra I, N. Jacobson	2nd Edition	Hindustan Publishing Co., 1984.
S25032 –RB5	Algebra I, S. Lang	3rd Ed 2005	Addison Wesley,
S25032 –RB6	Topics in Algebra, I N Herstein	2nd Ed	John Wiley
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25032 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25032-WL1			

S25033: INTEGRAL EQUATIONS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25033	Integral Equations	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Classify and solve integral equations • Apply integral equations to solve ODEs

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Introduction** **Integral Equation with Separable Kernel** **Method of Successive Approximation** **Resolvent Kernel**	**CR 01** **MLs** **01-20**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
02-01 02-02 02-03 02-04	**Application to Ordinary Differential Equations** **Dirac Delta function** **Green's function** **Modified Green's function**	**CR 02** **MLs** **21-40**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
03-01 03-02 03-03 03-04	**Symmetric kernels** **Bilinear Forms** **Hilbert-Schmidt theorem** **Symmetric Integral Equation**	**CR 03** **MLs** **41-60**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
04-01 04-02 04-03 04-04	**Singular Integral equations** **Integral Transforms** **Application of Laplace transform** **Application of Fourier transform**	**CR 04** **MLs** **61-80**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Introduction:** Regularity Conditions, Special kinds of kernels, Eigen values and Eigen functions	CR 01
1-2	**Integral equation with Separable Kernel:** Convolution integral, Reduction to a system of algebraic equations, Fredholm alternative	
1-3	**Method of Successive Approximation**: An approximate method, Iterative scheme, Volterra integral equation	
1-4	**Resolvent Kernel**: Some results about the Resolvent kernel	
2-1	**Application to Ordinary Differential Equations:** Initial value problems, Boundary value problems	CR 02
2-2	**Dirac Delta function:** Adjoint equation of second order linear equation and self adjoint equation, Dirac delta function	
2-3	**Green's Function**: Green's function approach, Green's function for Nth–order ordinary differential equation	
2-4	**Modified Green's Function:** Modified Green's function	
3-1	**Symmetric Kernels**: Introduction, Fundamental properties of eigenvalues and Eigen functions for symmetric kernels	CR 03
3-2	**Bilinear Forms**: Expansion in Eigen functions and bilinear form	
3-3	**Hilbert-Schmidt Theorem:** Hilbert-Schmidt theorem and some immediate consequences	
3-4	**Symmetric Integral Equation**: Solution of a symmetric integral equation	
4-1	**Singular Integral Equations**: Abel's equations, Inversion formula for singular integral equations	CR 04
4-2	**Integral Transforms:** Laplace transform, properties, Fourier transform, Properties	
4-3	**Application of Laplace Transform**: Applications to Volterra integral and integro-differential equations with convolution type kernels	
4-4	**Application of Fourier Transform**: Solution by Fourier transform method	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25033			
Text-Books			
S25033-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25033 –RB1	Linear Integral Equations R. P. Kanwal	1971	Academic Press
S25033 –RB2	Integral Equations, S. G. Mikhlin	1957	Pergamon Press
S25033 –RB3	A first Course in Integral Equations, A. M. Wazwaz	1997	World Scientific
S25033 –RB4	The Analysis of Linear Integral Equations, J. A. Cochran	1972	MC-Graw Hill
S25033 –RB5	Problems and Exercises in Integral Equations, M. A. Krasnow, Kislov and G. Hakaronke	1971	MIR Pub.
S25033 –RB6	Integral Equations: A short Course, Li, G Chambers	1976	International Textbook company
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25033 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25033-WL1			

S25034: Discrete Mathematics

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

Course Information

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25034	Discrete Mathematics	4	12	120	20	80	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Solve problems on permutation and combinations • Comprehend concepts of graph theory, Trees, Cut-sets • Elaborate properties of Boolean algebra, lattice and Boolean functions, Algebraic Systems defined by Lattices

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Permutations** **Combinations** **Generation of Permutations and Combinations** **Discrete Probability**	**CR 01** **MLs** **01-20**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
02-01 02-02 02-03 02-04	**Graphs** **Paths and Circuits** **Eulerian and Hamiltonian Paths and Circuits** **Planar Graphs**	**CR 02** **MLs** **21-40**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
03-01 03-02 03-03 03-04	**Trees** **Rooted and Binary Trees** **Spanning Trees** **Cut-Sets**	**CR 03** **MLs** **41-60**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
04-01 04-02 04-03 04-04	**Boolean Algebras: Lattices and Algebraic Systems** **Basic Properties of Algebraic Systems Defined by Lattices** **Boolean Lattices and Boolean Algebras** **Boolean Functions and Boolean Expressions**	**CR 04** **MLs** **61-80**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit { Exercises word should not be mentioned here as it is a part of each unit}	CR
1-1	**Permutations:** Introduction, Definitions, Circular Permutations, Permutations with repetitions, Exercises.	CR 01
1-2	**Combinations:** Introduction, Definitions, Exercises.	
1-3	**Generation of Permutations and Combinations:** Introduction, Definitions, Permutations and Combinations with unlimited repetitions, Exercises.	
1-4	**Discrete Probability:** Sample space, Discrete Sample space, Simple and Compound event, Exercises.	
2-1	**Graphs and Planar Graphs:** Introduction to graph theory, types of graphs, Basic terminology, Subgraphs, Graph isomorphism, Connectedness in simple graphs, Matrix representation of graphs, Exercises.	CR 02
2-2	**Paths and Circuits:** Distance in graphs: Eccentricity, Radius, Diameter, Center, Weighted graphs Dijkstra's algorithm to find the shortest distance paths in graphs and digraphs, Exercises.	
2-3	**Eulerian and Hamiltonian Graphs:** Necessary and sufficient conditions for Euler circuits and paths in simple, undirected graphs. Some applications of graphs, Traveling Salesman's Problem, Nearest neighbor method, Exercises.	
2-4	**Planar Graphs:** Euler's formula. Kuratowski's theorem, Non planar graphs, Detection of Planarity, Geometric Dual, Coloring of graphs, Chromatic number, Chromatic polynomial, Exercises.	
3-1	**Trees:** Elementary properties of trees, Center, Pendant Vertices in a Tree, Distance and Centers in a Tree, Minimally connected graph, Exercises.	CR 03
3-2	**Rooted and Binary Trees:** Rooted trees, Binary trees, Trees as models. Properties of trees.	
3-3	**Spanning Trees Minimum spanning trees:** Minimum spanning trees. Fundamental Circuits, finding all Spanning Trees of a Graph, Spanning Trees in a Weighted Graph, Prim's and Kruskul's Algorithms, Exercises.	
3-4	**Cut-Sets:** Cut-vertex, Cut-Edge, Some Properties of a Cut-Set, Fundamental circuits and cut-sets, Connectivity and Separability, Exercises.	
4-1	**Lattices and Algebraic Systems:** Introduction, Principle of Duality, Properties of Lattices, Lattice as an Algebraic system, Sub Lattice, Bounded Lattice, Complements, Complete Lattice, Exercises.	CR 04
4-2	**Basic Properties of Algebraic Systems Defined by Lattices:** Distributive Lattice, Complemented Lattice, Isomorphic Lattice, Modular Lattice, Exercises.	
4-3	**Boolean Lattices and Boolean Algebras:** Properties of Boolean Algebra, Boolean sub-algebra, Homomorphism of Boolean Algebra, Order relation in Boolean Algebra, Exercises.	
4-4	**Boolean Functions and Boolean Expressions:** Fundamental forms of Boolean functions, Normal forms of Boolean functions, Disjunctive and Conjunctive normal form Examples, Exercises.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25034			
Text-Books			
S25034-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25034 –RB1	Elements of Discrete Mathematics, Liu, C L. (Chung Laung)	2nd Edition1985	0-07-038133-X
S25034 –RB2	Discrete mathematics with graph theory, Edgar G. Goodaire, Michael M. Parmenter	2nd Edition2002	0-13-092000-2
S25034 –RB3	Discrete Mathematics and its Applications Kenneth H. Rosen	7thEdition2012	978-0-07-338309-5
S25034 –RB4	Graph Theory, F. Harary	1969	Addition Wesley

S25034 –RB5	A First look at Graph Theory, John Clark and Derek Allan Holton	1991	Prentice Hall 81-7023-463-8
S25034 –RB6	Graph Theory With Applications to Engineering and Computer Science, N. Deo	1974	Prentice Hall of India 0-13-363473-6
S25034 –RB7	Boolean Algebra and Graph Theory J N Salunke	2000	Laxmi Prakashan
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25034 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25034-WL1			

S25035: Operations Research

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

Course Information

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25035	Operations Research	4	12	120	20	80	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Understand the theory of convex sets, functions, formulation of LPP, techniques of integer and non-integer solution of Linear and nonlinear programming problems. • Use quantitative methods and techniques for effective decisions– making • Develop model formulation and applications that are used in solving business decision problems.

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Operations Research and its scope** **Linear Programming Problems** **Simplex Method** **Duality Theory and Dual Simplex Method**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
02-01 02-02 02-03 02-04	**Game Models and Related Theory** **Two Person Zero Sum Game** **Dominance in Games** **Mixed Strategies(2×n and m×2 games)**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
03-01 03-02 03-03 03-04	**Network Analysis** **Fulkerson's Rule** **Critical Path Method (CPM)** **Programme Evaluation and Review Technique (PERT)**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
04-01 04-02 04-03 04-04	**Simulation Theory** **MONTE CARLO Method** **Generation of Random Numbers** **Simulation Languages**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Operations Research and its Scope**: Definition, Characteristics, Necessity of Operations Research in Industry, Scope of Operations Research.	CR 01
1-2	**Linear Programming Problems:** Formulation of LPP, Graphical Method of LPP solution.	
1-3	**Simplex Method:** Computational details of Simplex method, Artificial Starting Solution.	
1-4	**Duality Theory and Dual Simplex Method:** Definition, Formulation of Dual, Dual Simplex Algorithm.	
2-1	**Game Models and Related Theory:** Definition, Characteristics of Games, Types of Strategies.	CR 02
2-2	**Two Person Zero Sum Game:** Maximin and Minimax Principles, Saddle Point, Solution of game with and without saddle point.	
2-3	**Dominance in Games:** Rules for Dominance, Reduction of games by Dominance.	
2-4	**Mixed Strategies(2×n and m×2 games):** Algebraic method and Subgame method for solving 2×n and m×2 games	
3-1	**Network Analysis:** Definition, Symbols, Drawing Network diagrams, Analysis of Network diagrams.	CR 03
3-2	**Fulkerson's Rule:** Numbering the Events, Fulkersons Rule.	
3-3	**Critical Path Method (CPM):** Objects of CPM, Labelling Method, Critical Path Analysis.	
3-4	**Programme Evaluation and Review Technique (PERT):** Time Estimates, Frequency Distributions for PERT, PERT Technique.	
4-1	**Simulation Theory:** When to use Simulation, What is Simulation, Advantages and Limitations of Simulation, Applications of Simulation.	CR 04
4-2	**MONTE CARLO Method:** General procedure for MONTE CARLO Method, Advantages and Disadvantages of MONTE CARLO Method, Applications.	
4-3	**Generation of Random Numbers:** Methods of finding Random Numbers, Mixed Congruence Method, Multiplicative Congruential Method.	
4-4	**Simulation Languages:** Languages used for Simulation.	
	Transportation, Inventory, Sequencing and Assignment problems (To be added in this course content, flexibility given to author to maintain logical flow while adding them)	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25035			
Text-Books			
S25035-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25035 –RB1	Operations Research, P. K. Gupta and D. S. Hira		S Chand and Company Limited, New Delhi.
S25035 –RB2	Operations Research An Introduction, Taha	9th Edition	Pearson
S25035 –RB3	Operations Research, B. S. Goel, S. K. Mittal,		Pragati Prakashan
S25035 –RB4	Linear Programming, G. Hardley,		Oxford and IBH Publishing Co
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25035 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25035-WL1			

SEMESTER 04

S25041: DIFFERENTIAL GEOMETRY

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25041	Differential Geometry	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Describe curves and surfaces and label their equations • Represent the curves and surfaces in different forms and identify their nature • Construct various surfaces • Compute various parameters related to curves and surfaces and justify their behavior

UNITS

UN	Name of the Unit [Updated as per ebook on 2June 2021]	CSs	Questions
01-01 01-02 01-03 01-04	**Euclidean Space** **Curves** **Frenet Apparatus and Frenet Formulae** **Isometries of R^3**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**Covariant Derivative** **Surfaces in R^3** **Patch computation of a Surface** **Shape Operator**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**Gaussian and Mean Curvatures** **Gauss Map** **Fundamental Forms** **Geodesic Curvature**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**Some Special Curves on a Surface** **Geodesic Differential Equations** **Isometry of Surfaces** **Surfaces of Constant Curvature**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit	CR
1-1	**Euclidean Space**: Euclidean space of 3- dim., Tangent vectors and vector fields on R^3, Natural coordinate functions, Natural frame fields, Euclidean coordinate functions, Directional derivative.	CR 01
1-2	**Curves:** Plane curves, velocity vector to a curve, reparametrisation of a curve, Regular curve, arc length of a curve, unit speed reparametrisation, Frame, Norm of a vector, Euclidean distance,	

	Vector field on a curve, Parallel vector field on a curve.	
1-3	**Frenet Apparatus and Frenet Formulae:** Frenet frame field, The Frenet formulae for the unit speed curve, Spherical curve, Frenet formulae for arbitrary speed curve, Cylindrical Helix.	
1-4	**Isometries of R^3**: Isometry, Translation, Rotation, Orthogonal transformation.	
2-1	**Covariant derivative**: Covariant derivative of a vector field, Properties of covariant derivative, Lie bracket.	**CR 02**
2-2	**Surfaces in R^3:** Regular mapping, Coordinate patch and proper patch, Surface, Monge patch, Criteria for a surface, surface of revolution.	
2-3	**Patch Computation of a Surface**: Patch computation, Parametrisation of a region X(D) in M, Parametrisation of a surface of revolution, Torus of revolution, Tangents and normal, Normal vector field on a surface.	
2-4	**Shape Operator:** Shape operator, Normal Curvature, Normal section of a surface, Principal curvature, Principal direction, Umbilic points, Euler's Theorem.	
3-1	**Gaussian and Mean Curvatures:** Gaussian curvature and Mean curvature, Flat space, Minimal space, Computational techniques, Sign of Gaussian curvature.	**CR 03**
3-2	**Gauss Map:** Gauss map, Quadric surface, Geometrical interpretation of Principal curvature.	
3-3	**Fundamental Forms:** Arc length of a curve on a surface, The first and the second fundamental forms of a surface, Computation of a normal curvature of a curve on a surface patch.	
3-4	**Geodesic Curvature:** Geodesic curvature of a curve on a surface, Relation between the curvature, normal curvature and the geodesic curvature of a curve on a surface, Expression for geodesic curvature of a curve on a surface, shape operator for the Cartesian equation of the surface, Gaussian and mean curvatures of Cartesian equation of a surface.	
4-1	**Some Special Curves on a Surface**: Lines of Curvature, Differential equation of lines of curvature, Asymptotic directions and asymptotic curves, Characterization of an asymptotic curve, Geodesics.	**CR 04**
4-2	**Geodesic Differential Equations:** Differential equations of a geodesic, Geodesic as a shortest path, Conditions for parametric curves to be geodesics, Geodesic parallels.	
4-3	**Isometries of Surfaces**: Isometry of surfaces, Conformal mapping, Gauss's Remarkable Theorem.	
4-4	**Surfaces of Constant Curvature:** Surfaces of constant Gaussian curvature, Weingarten Equations, Surfaces of constant mean curvature, Gauss Equations, Codazzi-Mainardi equations.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25041			
Text-Books			
S25041-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25041 –RB1	An introduction to Differential Geometry, T J Wilmore		Oxford University Press
S25041 –RB2	Elementary Differential Geometry, Andrew Pressley	2009	Springer-Verlag, London. 978-81-8128-143-2
S25041 –RB3	Elementary Differential Geometry, Barrat O'Neill	2006	Academic Press, 978-0-12-088735-4
S25041 –RB4	Differential Geometry- First Course, D. Somasundaram	2010	Narosa Publishing House, New Dehli.
S25041 –RB5	Differential Geometry C Weatherburn		
S25041 –RB6	Differential Geometry, K. S. Amur and et al	2010	Narosa Publishing House, New Dehli.

S25041 –RB7	Elements of Differential Geometry, Millman, R. and Parker, G. D	1977	Prentice-Hall of India Pvt. Ltd.
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25041 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25041-WL1	NPTEL, SWAYAM		

S25042: FUNCTIONAL ANALYSIS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25042	Functional Analysis	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Know the concepts of normed spaces, Banach space and Hilbert spaces • Explain how the notion of norm induces metric on a linear space and then think of sequences, continuity and completeness over linear spaces • Apply uniform boundedness principal, Hahn-Banach theorem for solution of differential equations.

UNITS

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Banach Spaces** **Continuous Linear Transformation** **The Hahn Banach Theorem** **The Natural Embedding of N in N****	**CR 01** **MLs** **01-20**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
02-01 02-02 02-03 02-04	**The Open Mapping Theorem** **The Conjugate of an Operator** **Hilbert Spaces** **Orthogonal Complements, Orthonormal Sets**	**CR 02** **MLs** **21-40**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
03-01 03-02 03-03 03-04	**The Conjugate Space H*** **The Adjoint of an Operator** **Different Types of Operators** **Projections**	**CR 03** **MLs** **41-60**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR
04-01 04-02 04-03 04-04	**Spectral Resolution of T** **Matrices** **The Determinant and Spectrum of an Operator** **The Spectral Theorem**	**CR 04** **MLs** **61-80**	Student is required to answer 4 of 5 SAQ, **each** of 5 marks, on **each** CR

Detailed Syllabus

UN	Detailed Syllabus of the Unit	CR
1-1	**Banach Spaces**: Normed linear space, Banach space, The definition and examples, construction of new normed spaces.	CR 01
1-2	**Continuous Linear Transformation**: Bonded, Continuous linear transformation some definitions and theorems.	
1-3	**The Hahn Banach Theorem**: Conjugate Space, Functional, Lemma, The Hahn Banach Theorem and its consequences.	
1-4	**The Natural Embedding of N in N**:** Second conjugate space, Natural imbedding of N in N**, Reflexive space, Compact Hausdorff of the closed unit sphere.	
2-1	**The Open Mapping Theorem:** Definitions of Open Sphere, Open Map, Lemma, Open mapping theorem, Closed graph theorem and their consequences.	CR 02
2-2	**The Conjugate of an Operator:** Conjugate of an operator, Uniform boundedness theorem, and its consequences.	
2-3	**Hilbert Spaces:** The definition and examples of Hilbert space, Schwarz inequality, Parallelogram law for Hilbert spaces and its applications.	
2-4	**Orthogonal Complements, Orthonormal Sets:** Orthogonal complement, Pythagorean theorem, Orthonormal sets, Bessels inequality and its consequences, Gram-Schmidt Orthogonalization.	
3-1	**The Conjugate Space H*:** The conjugate space H*, Natural correspondence between H and H*; H and H**.	CR 03
3-2	**The Adjoint of an Operator:** Difference between the conjugate and adjoint of T, Arithmetic and norm properties of adjoint operation.	
3-3	**Different Types of Operators:** Self adjoint operators, Normal and Unitary operators, Existence of non-normal operators, Geometric significance of the operators.	
3-4	**Projections:** Projections, Perpendicular projection, Reduceness of closed linear subspace, Sum of projections.	
4-1	**Spectral Resolution of T:** Eigen value and eigen vector of an operator, Spectral resolution of T.	CR 04
4-2	**Matrices:** Definitions of nonsingular matrix, Similar matrices, Matrix algebra etc, non-singularity of the operator T.	
4-3	**The Determinant and Spectrum of an Operator:** Properties of determinant, Spectrum of an operator, eigenvalues of the operator T.	
4-4	**The Spectral Theorem:** Definition of spectral resolution of T, Mi reduces T, The Spectral theorem, Uniqueness theorem.	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25042			
Text-Books			
S25042-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25042 –RB1	Introduction to Topology and Modern Analysis , G. F. Simmons	1963	Tata Mc Graw Hill
S25042 –RB2	Functional Analysis, B.V. Limaye		Wiley Eastern Ltd.
S25042 –RB3	Foundations of Functional Analysis, S.Ponnusamy		Narosa Publishing House
S25042 –RB4	Functional Analysis, G. Bachman and L. Narici		Name of the publisher???

S25042 –RB5	Introductory Functional Analysis with Applications Kreyszig	1966	John Wiley & Sons
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25042 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25042-WL1			

S25043: CLASSICAL MECHANICS

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25043	Classical Mechanics	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Explain Euler's variational principles and will use to solve real life problems. • Apply D'Alembert's Principle, Lagrange's equation, Hamiltonians Principle, Hamilton's equation and Hamilton Jacobi equation to form differential equation as well as its solution of various real existing systems. • Formulate Poisson's brackets, Lagrange's bracket, canonical transformation for solution of equations.

UNITS

UN	Name of the Unit (Updated as per CM ebook--- Dr Karade Sir)	CSs	Questions
01-01 01-02 01-03 01-04	**Mechanics of System of Particles** **D'Alembert's Principle and Lagrange's Equations** **Central Force Motion** **Kepler's Laws and Virial Theorem**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
02-01 02-02 02-03 02-04	**Calculus of Variation** **Euler's Equation and its Applications** **Hamilton's Principle** **Hamilton's Equation of Motion**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
03-01 03-02 03-03 03-04	**Routh Procedure and the Least Action Principle** **Canonical Transformations** **Invariance under Canonical Transformations** **Lagrange and Poission Brackets**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR
04-01 04-02 04-03 04-04	**Rigid Body Motion- Rotations in Plane and Space** **Eulerian Angles** **A Moving Coordinate Frame** **Rotational Dynamics of a Rigid Body**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on each CR

DETAILED SYLLABUS

UN	Detailed Syllabus of the Unit {updated as per CM ebook }	CR
1-1	**Mechanics of a System of Particles:** Mechanics of a particle, Mechanics of a system of particles, Degrees of freedom and generalized coordinates.	CR 01
1-2	**D'Alembert's Principle and Lagrange's Equations:** D'Alembert's principle, Derivation of Lagrange's equations for conservative system, Generalized potential, Rayleigh's dissipation function	
1-3	**Central Force Motion:** Equivalent one body problem, Central force field, Motion in one dimension, Classification of central orbits, Differential equation for the orbit, Integrable power law force field	
1-4	**Kepler's Laws and Virial Theorem:** Kepler's first law, Kepler's second law, Kepler's third law, Virial theorem	
2-1	**Calculus of Variation:** Preliminaries, Functional, Continuity of a functional	CR 02
2-2	**Euler's Equation and its Applications:** Variation of y(x) and I[y(x)], An elementary problem in the CV, Invariance of Euler equation, Applications of Euler equation.	
2-3	**Hamilton's Principle:** Hamilton's principle for conservative system, Extension of Hamilton's principle to nonconservative holonomic system, Lagrange's equation for nonholonomic conservative systems.	
2-4	**Hamilton's Equation of Motion:** Derivation of the Hamilton's canonical equations, Hamilton's equations from variational principle.	
3-1	**Routh Procedure and the Least Action Principle:** Routhian of a mechanical system, The least action principle.	CR 03
3-2	**Canonical Transformations:** Some transformations, Canonical or contact transformations, Generating function of a canonical transformation.	
3-3	**Invariance under Canonical Transformations:** Bilinear covariant of the Pfaffian differential form, Theorem of Poincare, Infinitesimal canonical transformation	
3-4	**Lagrange and Poission Brackets:** Lagrange bracket, Poisson bracket, Equations of motion in Poisson bracket, Canonical invariance of the Poisson bracket, Jacobi identity, Angular momentum and Poisson brackets, Relation between Lagrange and Poisson brackets	
4-1	**Rigid Body Motion- Rotations in Plane and Space:** Preliminaries, Rotations in the plane, Rotations in 3-space.	CR 04
4-2	**The Euler Angles:** Transformation matrix in terms of Euler angles, The Euler's theorem, Finite rotations, Infinitesimal rotations.	
4-3	**A Moving Coordinate Frame:** Translational accelerated frame, A rotating coordinate frame, Acceleration in a rotating system, Application to the rotating earth	
4-4	**Rotational Dynamics of a Rigid Body:** Mathematical back ground, Angular momentum and inertia tensor, Principal axes, The Euler equations of motion.	

LEARNING RESOURCE DETAILS

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25043			
Text-Books			
S25043-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25043 –RB1	Classical Mechanics, H. Goldstein	1980	Narosa
S25043 –RB2	Classical Mechanics, Gupta, Kumar, Sharma	2006	Pragati
S25043 –RB3	Calculus of variations with application to Physics & Engineering, Robert Weinstock	1952	McGrow-Hill book comp.

S25043 –RB4	A treatise on Classical Mechanics T M Karade and Nilay T Karade	2019	Sonu Nilu Publication, Nagpur
S25043 –RB5	Problem Book in Classical Mechanics L N Katkar	2014	Narosa Publication, New Delhi
CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25043 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25043-WL1			

S25044: CRYPTOGRAPHY

PROGRAMME INFORMATION

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

COURSE INFORMATION

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25044	Cryptography	4	12	120	20	80	100	T

PRESUMED KNOWLEDGE AND LEARNING OBJECTIVES

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Use various primality tests, encryption and decryption algorithms • Apply arithmetic of elliptic curves in cryptography • Use ways of doing secret communication

UNITS

UN	Name of the Unit	CSs	Questions
	Some topics in Elementary Number Theory	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
01-01	**Time Estimates for doing Arithmetic**		
01-02	**Divisibility and the Euclidean Algorithm**		
01-03	**Congruences**		
01-04	**Some Applications to Factoring**		
	Finite fields and Quadratic Residues	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
02-01	**Finite Fields**		
02-02	**Quadratic Residues and Quadratic Reciprocity**		
02-03	**Some Simple Cryptosystems**		
02-04	**Enciphering Matrices**		
	Public Key, Primality and Factoring	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
03-01	**The Idea of Public Key Cryptography**		
03-02	**RSA Cryptosystem**		
03-03	**Discrete Log**		
03-04	**Pseudoprimes, The rho method**		
	Elliptic Curves	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
04-01	**Basic Facts**		
04-02	**Elliptic Curve Cryptosystems**		
04-03	**Elliptic Curve Primality Test**		
04-04	**Elliptic Curve Factorization**		

Detailed Syllabus

UN	Detailed Syllabus of the Unit (Red colour content to be deleted as repeated in Number Theory...Add new contents, ebook author should take responsibility)	CR
1-1	**Time Estimates for doing Arithmetic**: Numbers in different bases, Number of digits, bit operations, The big-O notation	CR 01
1-2	**Divisibility and the Euclidean Algorithm**: Divisors and divisibility, The Euclidean algorithm	
1-3	**Congruences**: Basic Properties, Fermat's little theorem, Chinese Reminder theorem, Modular exponentiation by the repeated squaring method	
1-4	**Some Applications to Factoring**: Factoring certain types of large integers	
2-1	**Finite Fields**: Existence of multiplicative generators of finite fields, Existence and uniqueness of finite fields with prime power number of elements	CR 02
2-2	**Quadratic Residues and Quadratic Reciprocity**: Roots of unity, Quadratic Residues, The Legendre symbol, Law of quadratic Reciprocity, The Jacobi symbol, Square roots modulo p	
2-3	**Some Simple Cryptosystems**: Basic Notions with Examples	
2-4	**Enciphering Matrices**: Linear algebra modulo N, Affine enciphering transformations	
3-1	**The idea of public key cryptography**: Classical verses public key, Hash function.	CR 03
3-2	**RSA Cryptosystem**: Definition, Algorithm and example	
3-3	**Discrete Log**: Definition, The Diffie-Hellman key exchange system, The ElGamal cryptosystem, Algorithms for discrete log problem-Shank's algorithm, The Pollard rho algorithm	
3-4	**Pseudoprimes, The rho method**: Definition, Carmichael number, Euler pseudoprimes, Strong pseudoprimes, Miller-Rabin primality test, The rho method	
4-1	**Basic Facts**: Definition of elliptic curve over R, Points of finite order, Elliptic curves over a finite field.	CR 04
4-2	**Elliptic Curve Cryptosystems**: Multiples of points, Analog of the Diffie-Hellman key exchange, Analog of ElGamal	
4-3	**Elliptic Curve Primality Test**: Test due to Pocklington, Elliptic curve primality test	
4-4	**Elliptic Curve Factorization**: Pollard's p-1 method, Elliptic curves-reduction modulo n	

Learning Resource Details

LR Code	Title Author	Edition Year	ISBN Publisher
Course Website Link for (1) Mobile and Online Lectures, (2) Discussion Forum for online interaction and (3) Self-Test for each CR Block, Continuous Assessment Test and End Examination			
CW-S25044			
Text-Books			
S25044-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25044 –RB1	A Course in Number Theory and Cryptography, Neal Koblitz	1994 3rd Indian Reprint, 2008	978-81-8128-230-9, Springer
S25044 –RB2	Cryptography Theory and Practice, Douglas Stinson	2006 3rd Indian Reprint, 2015	1-58488-508-4
S25044 –RB3	An Introduction to Mathematical Cryptography, J. Hoffstein, J. Pipher, J. H. Silverman	2nd Ed, 2014	978-1-4939-1710-5, Springer
S25044 –RB4	Introduction to Cryptography, J. A. Buchmann,	2001, 2nd Ed (Indian Reprint, 2005)	81-8128-232-9, Springer

CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25044 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25044-WL1			

S25045: Topics in Fuzzy Mathematics

Programme Information

SN	Description	Details
1	University	Yashwantrao Chavan Maharashtra Open University Nashik - 422 222, Maharashtra, India Website: http://www.ycmou.ac.in/and http://ycmou.digitaluniversity.ac/
2	School	School of Architecture, Science and Technology
3	Discipline	Science
4	Level	PG
5	Course Used in	V57: M.Sc.(Maths)

Course Information

Sem	Code	Course Name	CR	CST	ST	CA	EE	TM	Type
01	S25045	Topics in Fuzzy Mathematics	4	12	120	20	80	100	T

Presumed Knowledge and Learning Objectives

Presumed Knowledge	Learning Objectives
For successful completion of this course, student should have successfully complete: • BSc/BA with Mathematics or equivalent from a recognized University/Board.	After successful completion of this course, student should be able to • Apply the concepts of fuzzy sets, algebra of fuzzy sets and extension principal. • Explain generalize notions of fuzzy union, intersection and fuzzy complementation and their properties. • Apply fuzzy relations, fuzzy arithmetic's, fuzzy relation equations and fuzzy logic for real life problems

Units

UN	Name of the Unit	CSs	Questions
01-01 01-02 01-03 01-04	**Fuzzy Sets and Crisp Sets** **Convex Fuzzy Sets** **Extension Principle** **Fuzzy Complementation**	CR 01 MLs 01-20	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
02-01 02-02 02-03 02-04	**Fuzzy Intersections and Unions** **Dual triplets and Aggregation operations** **Fuzzy Arithmetic** **Lattice of Fuzzy Numbers and Fuzzy Equations**	CR 02 MLs 21-40	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
03-01 03-02 03-03 03-04	**Fuzzy Relations** **Fuzzy Equivalence Relations** **Composition of Fuzzy Relations** **Fuzzy Relation Equations**	CR 03 MLs 41-60	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR
04-01 04-02 04-03 04-04	**More Fuzzy Relations Equations and Approximate Solutions** **Fuzzy Propositions** **Fuzzy Quantifiers** **Approximate Reasoning**	CR 04 MLs 61-80	Student is required to answer 4 of 5 SAQ, each of 5 marks, on eachCR

Detailed Syllabus

UN	Detailed Syllabus of the Unit (Add fuzzy logic)	CR
1-1	**Fuzzy Sets and Crisp Sets**: Definitions, α-cuts, Basic Operations on Fuzzy Sets, cardinality, degree of subset-hood, types of fuzzy sets, Cartesian products, algebraic products bounded sum and difference.	
1-2	**Convex Fuzzy Sets**: Properties of α-cuts, Convex fuzzy sets, Decomposition theorems	
1-3	**Extension principle:** Image and Pre-image of fuzzy sets under crisp function, Properties with α-cuts, Extension of the principle for pair of sets	CR 01
1-4	**Fuzzy Complementation**: Definition Examples, Equilibrium and dual points with respect to fuzzy complement, Increasing and Decreasing Generators, Characterization Theorem of Fuzzy Complements, More Examples of Fuzzy Complements.	
2-1	**Fuzzy Intersections and Unions**: Definition and Examples of fuzzy intersections or t-norms, Characterization theorems for t-norms, Definition and examples of fuzzy unions or t-conorms, Characterization theorems for t-conorms.	
2-2	**Dual Triplets and Aggregation Operations**: Dual triplets, characterization theorems for dual triplets, Aggregation operations and their properties.	
2-3	**Fuzzy Arithmetic**: Fuzzy Numbers, Types of Fuzzy Numbers, Elements of fuzzy arithmetic, Interval arithmetic, sum, difference, multiplications of fuzzy numbers, Lattice of fuzzy numbers.	CR 02
2-4	**Lattice of Fuzzy Numbers and Fuzzy Equations:** Maximum and Minimum of fuzzy numbers, Ordering on fuzzy numbers, Equations of the type $A + X = B$ *and* $A \cdot X = B$ with A, B are fuzzy numbers.	
3-1	**Fuzzy Relations**: Fuzzy Relations, Binary fuzzy relations, Composition of fuzzy relations, Max-min closure and its extension.	
3-2	**Fuzzy Equivalence Relations:** Definition and examples, Fuzzy computability relations, Fuzzy ordering.	
3-3	**Composition of Fuzzy Relations:** sup-t composition of fuzzy relations, inf-ω_i compositions, relation between sup-t and inf-ω_i compositions of fuzzy binary operations.	CR 03
3-4	**Fuzzy Relation Equations:** max-min relation equations, sup-t relation equations.	
4-1	**More Fuzzy Relations Equations and Approximate Solutions**: inf-ω_i relation equations, Approximate solutions of fuzzy relation equations, Equality and solvability indices.	
4-2	**Fuzzy Propositions:** Unconditional and unqualified fuzzy propositions, Unconditional and qualified fuzzy propositions, Conditional and unqualified fuzzy propositions, Conditional and qualified fuzzy propositions, Truth values of compound fuzzy propositions.	CR 04
4-3	**Fuzzy Quantifiers**: Fuzzy Quantifiers, Linguistic hedges, Inference from conditional fuzzy propositions, Inference from conditional and qualified fuzzy propositions, Inference from quantified fuzzy propositions.	
4-4	**Approximate Reasoning:** Fuzzy Implications Definition and examples, Types of fuzzy propositions, Selection of fuzzy implications, Multi conditional approximate reasoning, Role of fuzzy relational equations.	

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CW-S25045			
Text-Books			
S25045-T01			
Reference-Books: Explore additional details and reinforce learning, with this optional learning resource!			
S25045 –RB1	Fuzzy Sets and Fuzzy Logic Theory and Applications, George J. Klir, Bo Yuan,	2000	PHI, Ltd. 0-13-101171-5
S25045 –RB2	Fuzzy Logic with Engineering Applications, T. J. Ross,	2010	McGraw Hill, International Editions,
S25045 –RB3	Fuzzy Sets Theory- and its Applications H J Zimmermann	1985	Springer
S25045 –RB4			

CD / DVD: Explore additional details and reinforce learning, with this optional learning resource!			
S25045 -CD1			
Web Links: Explore additional details and reinforce learning, with this optional learning resource!			
S25045-WL1			

END OF DOCUMENT