CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

DEGREE OF B. Sc. MATHEMATICS

BACHELOR OF SCIENCE IN MATHEMATICS

(CHOICE BASED CREDIT AND SEMESTER SYSTEM FOR UNDERGRADUATE CURRICULUM)

UNDER THE FACULTY OF SCIENCE

SYLLABUS

(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2020 – 21 ONWARDS)

BOARD OF STUDIES IN MATHEMATICS (UG)

CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA - 680125, KERALA, INDIA

JUNE, 2020

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11. Ms. Niveditha N.S, (Ad-hoc Faculty), Department of Mathematics, Christ College, Irinjalakuda.
12. Mr. Jomesh Jose K, (Ad-hoc Faculty), Department of Mathematics, Christ College, Irinjalakuda.
13. Ms. Anjaly V.A, (Ad-hoc Faculty), Department of Mathematics, Christ College, Irinjalakuda.

Syllabus Structure

Core Courses

The following courses are compulsory for BSc Mathematics programme.

Sl. No	Code	Name of the course	Semester	No of contact hours/ Week	Credits	Max. Marks			Exam dur. (Hrs.)
						Internal	External	Total	
1	MTS1B01	Basic Logic and Number Theory	1	4	4	20	80	100	2.5
2	MTS2B02	Calculus of Single Variable-1	2	4	4	20	80	100	2.5
3	MTS2B03	Calculus of Single Variable-2	3	5	4	20	80	100	2.5
4	MTS1B04	Linear Algebra	4	5	4	20	80	100	2.5
5	MTS5B05	Abstract Algebra	5	5	4	20	80	100	2.5
6	MTS5B06	Basic Analysis	5	5	4	20	80	100	2.5
7	MTS5B07	Numerical Analysis	5	4	3	15	60	75	2
8	MTS5B08	Linear Programming	5	3	3	15	60	75	2
9	MTS5B09	Introduction to Geometry And Theory Of Equations	5	3	3	15	60	75	2
		Project	5	2					
10		Open Course (Offered by Other Departments)	5	3	3	15	60	75	2
11	MTS6B10	Real Analysis	6	5	5	20	80	100	2.5
12	MTS6B11	Complex Analysis	6	5	5	20	80	100	2.5
13	MTS6B12	Calculus of Multi variable	6	5	4	20	80	100	2.5
14	MTS6B13	Differential Equations	6	5	4	20	80	100	2.5
15	MTS6B14	Elective	6	3	2	15	60	75	2
16	MTS6P15(PR)	Project Viva	6	2	2	15	60	75	2
		Total		68	58			1450	

Elective Courses

One of the following four courses can be offered in the sixth semester as an elective course Code MT6B14(E01), MT6B14(E02) and MT6B14(E03)).

Sl. No.	Code	Name of the course	Semester	No of contact hours/ Week	Credits	Max. Marks			Exam dur. (Hrs)
						Internal	External	Total	
1	MTS6B14(E01)	Graph Theory	6	3	2	15	60	75	2
2	MTS6B14(E02)	Topology of Metric spaces	6	3	2	15	60	75	2
3	MTS6B14(E03)	Mathematical Programming with Python and Latex	6	3	2	15	60	75	2

Open Courses

One of the following four courses can be offered in the fifth semester as an open course for students from other degree programmes (MT5D01, MT5D02, MT5D03 and MT5D04).

Sl. No.	Code	Name of the course	Semester	No. of contact hours/ Week	Credits	Max. Marks			Unty. exam Dur. (Hrs)
						Internal	External	Total	
1	MTS5D01	Applied Calculus	5	3	3	15	60	75	2
2	MTS5D02	Discrete Mathematics for Basic and Applied Sciences	5	3	3	15	60	75	2
3	MTS5D03	Linear Mathematical Models	5	3	3	15	60	75	2
4	MTS5D04	Mathematics for Decision Making	5	3	3	15	60	75	2

Complementary Courses

Sl. No.	Code	Name of the course	Semester	No of contact hours/ Week	Credits	Max. Marks			Unty. exam Dur. (Hrs)
						Internal	External	Total	
1	MTS1C01	Mathematics-1	1	4	3	15	60	75	2
2	MTS2C02	Mathematics-2	2	4	3	15	60	75	2
3	MTS3C03	Mathematics-3	3	5	3	15	60	75	2
4	MTS4C04	Mathematics-4	4	5	3	15	60	75	2

Credit and Mark Distribution of BSc Mathematics Programme

<table>
<tr><th>Sl. No</th><th colspan="2">Course</th><th colspan="2">Credits</th><th colspan="2">Marks</th></tr>
<tr><td>1</td><td colspan="2">English</td><td colspan="2">22</td><td colspan="2">550</td></tr>
<tr><td>2</td><td colspan="2">Additional Language</td><td colspan="2">16</td><td colspan="2">400</td></tr>
<tr><td rowspan="3">3</td><td rowspan="3">Core Course</td><td>13 Courses</td><td>51</td><td rowspan="3">55</td><td>1225</td><td rowspan="3">1375</td></tr>
<tr><td>1 Elective</td><td>2</td><td>75</td></tr>
<tr><td>Project</td><td>2</td><td>75</td></tr>
<tr><td>4</td><td colspan="2">Complementary course I</td><td colspan="2">12</td><td colspan="2">300</td></tr>
<tr><td>5</td><td colspan="2">Complementary course II</td><td colspan="2">12</td><td colspan="2">300</td></tr>
<tr><td>6</td><td colspan="2">Open Course</td><td colspan="2">3</td><td colspan="2">75</td></tr>
<tr><td colspan="3">Total</td><td colspan="2">120</td><td colspan="2">300
0</td></tr>
</table>

Scheme of Evaluation

The evaluation scheme for each course shall contain two parts: internal evaluation and external evaluation.

Internal Evaluation

20% of the total marks in each course are for internal evaluation. The colleges shall send only the marks obtained for internal examination to the university.

Components of Internal Evaluation

Sl. No.	Components	Marks (For Courses with Max. Marks 75)	Marks (For Courses with Max. Marks 100)
1.	Class Room Participation (Attendance)	3	4
2.	Assignment	3	4
3.	Seminar	3	4
4.	Test paper	6	8
	Total	15	20

a) Percentage of Class Room Participation (Attendance) in a Semester and Eligible Internal Marks

% of C1ass Room Participation (Attendance)	Out of 3 (Maximum internal marks is 15)	Out of 4 (Maximum internal marks is 20)
$50\% \leq CRP < 75\%$	1	1
$75\% \leq CRP < 85\%$	2	2
85% and above	3	4

CRP means % of class room participation (Attendance)

a) Percentage of Marks in a Test Paper and Eligible Internal Marks

Range of Marks in test paper (TP)	Out of 6 (Maximum internal marks is 15)	Out of 8 (Maximum internal marks is 20)
Less than 35%	1	1
$35\% \leq TP < 45\%$	2	2
$45\% \leq TP < 55\%$	3	3
$55\% \leq TP < 65\%$	4	4
$65\% \leq TP < 85\%$	5	6
$85\% \leq TP \leq 100\%$	6	8

Evaluation of Project

1. Evaluation of the Project Report shall be done under Mark System.
2. The evaluation of the project will be done at two stages:
   - Internal Assessment (supervising teachers will assess the project and award internal Marks)
   - External evaluation (external examiner appointed by the University)
3. Grade for the project will be awarded to candidates, combining the internal and external marks.

4. The internal to external components is to be taken in the ratio 1:4.

Assessment of different components may be taken as below.

Internal assessment of Project (15 Marks)

(Supervising Teacher will assess the Project and award internal Marks)

Sl. No.	Components	Internal Marks
1	Originality	3
2	Methodology	3
3	Scheme / Organization of Report	4.5
4	Viva Voce	4.5
Total		15

External Evaluation of Project (60 Marks)

(To be done by the External Examiner appointed by the University)

Sl. No.	Components	External Marks
1	Relevance of the Topic, Statement of Objectives	12
2	Reference/Bibliography, Presentation, quality of Analysis/ Use of Statistical Tools.	12
3	Findings and recommendations	18
4	Viva-Voce	18
Total		60

Pattern of Question Paper for End Semester Examinations

	For Courses with Max. External Marks 80 (2.5 Hrs)		For Courses with Max. External Marks 60 (2 Hrs)	
Section A	Short answer type carries 2 marks each - 15 questions	Ceiling - 25	Short answer type carries 2 marks each - 12 questions	Ceiling - 20
Section B	Paragraph/ Problem type carries 5 marks each - 8 questions	Ceiling - 35	Paragraph/ Problem type carries 5 marks each - 7 questions	Ceiling - 30
Section C	Essay type carries 10 marks (2 out of 4)	$2 \times 10 = 20$	Essay type carries 10 marks (1 out of 2)	$1 \times 10 = 10$
Total		80		60

Questions are to be evenly distributed over the entire syllabus. At least 20% of questions from each module must be included in each section of the question paper for courses having four modules in the syllabus and 30% for courses having three modules in the syllabus.

CORE COURSES

SEMESTER 1

MT1 B01 - BASIC LOGIC & NUMBER THEORY

Number of Credits: 4

Contact Hours per week: 4

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 (Text 1) **15 hours**

1. Propositions - *de#inition*, *Boolean (logic) variables*, Truth Value, Conjunction, *Boolean expression*, Disjunction (*inclusive and exclusive*), Negation, Implication, Converse, Inverse and Contra positive, Biconditional statement, Order of Precedence, Tautology Contradiction and Contingency [‘Switching Networks’ omitted]
2. Logical equivalences - *laws of logic* [‘Equivalent Switching Networks’ *‘Fuzzy logic’* & *‘Fuzzy decisions’* omitted]
3. Quanti^iers - *universal & existential, predicate logic*
4. Arguments- valid and invalid arguments, *inference rules*
5. Proof Methods – vacuous proof, trivial proof, direct proof, indirect proof-*contrapositive & contradiction*, proof by cases, Existence proof- *constructive & non constructive, counter example*

Module 2 (Text 2) **12 hours**

1. Mathematical induction- well ordering principle, simple applications, weak version of principle of mathematical induction, illustrations, strong version of induction (second principle of MI), illustration
2. Recursion- recursive definition of a function, illustrations
3. The division algorithm – statement and proof, div & mod operator, card dealing, The two queens puzzle (simple applications), pigeonhole principle and division algorithm, divisibility relation, illustration, divisibility properties, union intersection and complement-inclusion-exclusion principle & applications, even and odd integers

4. Prime and Composite Numbers- definitions, infinitude of primes, [‘algorithm 2.4‘ omitted] The sieve of Eratosthenes, a number theoretic function, prime number theorem (statement only), distribution of primes (upto and including Example 2.25) . [rest of the section omitted]

Module 3 (Text 2) **17 hours**

1. Greatest Common Divisor- gcd, symbolic definition, relatively prime integers, Duncan’s identity, Polya’s theorem, infinitude of primes, properties of gcd, linear combination, gcd as linear combination, an alternate definition of gcd, gcd of n positive integers, a linear combination of n positive integers, pairwise relatively prime integers, alternate proof for infinitude of prime.

2. The Euclidean Algorithm- The Euclidean algorithm [algorithm 3.1 omitted], A jigsaw puzzle, Lame’s theorem (statement only; proof omitted)

3. The Fundamental Theorem of Arithmetic- Euclid’s lemma on division of product by a prime, fundamental theorem of arithmetic, Canonical Decomposition, number of trailing zeros, highest power of a prime dividing!, [only statement of Theorem3.14 required; proof omitted] Distribution of Primes Revisited, Dirichlet’s Theorem (statement only)

4. Least Common Multiple- *definition, canonical decomposition to find lcm, relationship between gcd and lcm, relatively prime numbers and their lcm*

5. Linear Diophantine Equations – *LDE in two variables*, *conditions to have a solution*, *Aryabhatta’s method*, *number of solutions*, *general solution*, *Mahavira’s puzzle*, *hundred fowls puzzle*, Monkey and Coconuts Puzzle, *[‘Euler’s method for solving LDE’s ‘ omitted]* Fibonacci numbers and LDE, *LDE in more number of variables and their solutions- Theorem 3.20*

Module 4 (Text 2) **20 hours**

1. Congruences - congruence modulo m, properties of congruence, characterization of congruence, least residue, [‘Friday-the-Thirteenth’ omitted], congruence classes, A Complete Set of Residues Modulo m, properties of congruence, use of congruence to find the remainder on division, [‘Modular Exponentiation’ method omitted], Towers of Powers Modulo m, further properties of congruence and their application to find remainder [‘Monkey and Cocunut Puzzle revisited’(example 4.17) omitted] congruences of two numbers with different moduli
2. Linear Congruence- solvability, uniqueness of solution, incongruent solutions, Modular Inverses, applications

3. Divisibility Tests-Divisibility Test for 10, Divisibility Test for 5, Divisibility Test for 2i , Divisibility Tests for 3 and 9, Divisibility Test for 11 [rest of the section from Theorem 5.1 onwards omitted]

4. Wilson's Theorem- self invertible modulo prime, Wilson's theorem and its converse ['Factorial, Multifactorial and Primorial Primes' omitted]
5. Fermat's Little Theorem(FLT)- FLT and its applications, [Lagrange's alternate proof of Wilson's theorem omitted], inverse of a modulo p using FLT, application-solution of linear congruences [' Factors of 2n + 1 ' omitted], extension of FLT in various directions ['The Pollard p-1 factoring method' omitted]
6. Euler's Theorem- motivation, Euler's Phi Function φ, Euler's Theorem, applications, generalisation of Euler's theorem (koshy)

References:

1. Susanna S Epp: Discrete Mathematics with Applications (4/ e)

2. Kenneth H. Rosen: Discrete Mathematics and Its Applications(7/e) *McGraw-Hill, NY (2007) ISBN: 978-0-07-338309-5*

3. David M. Burton: Elementary Number Theory(7/e) *McGraw- Hill (2011) ISBN: 978-0-07-338314-9*

4. Gareth A. Jones and J. Mary Jones: Elementary Number Theory, *Springer Undergraduate Mathematics Series (1998) ISBN: 978-3-540-76197-6*

5. Underwood Dudley: Elementary Number Theory(2/e),

6. James K Strayer: Elementary Number Theory, *Waveland Press, inc*. (1994), *ISBN:978-1-57766-224-2*

7. Kenneth H. Rosen: Elementary Number Theory (6/e), *Pearson Education (2018) ISBN: 9780134310053*

Textbooks:

1. Discrete Mathematics with Applications: Thomas Koshy, *Elsevier Academic Press (2004) ISBN:0-12-421180-1*

2. Elementary Number Theory with Applications (2/e): Thomas Koshy, *Elsevier Academic Press (2007) ISBN:978-0-12-372487-8*

SEMESTER 2

MTS2 B02 CALCULUS OF SINGLE VARIABLE-1

Number of Credits: 4

Contact Hours per week: 4

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 **20 Hours**

(Functions and Limits)

1. 0.2 Functions and their Graphs- Definition of a Function, Describing Functions, Evaluating Functions, Finding the Domain of a Function, The Vertical Line Test, Piecewise Defined Functions, Even and Odd Functions (quick review)

2. 0.4 Combining functions- Arithmetic Operations on Functions, Composition of Functions, Graphs of Transformed Functions*, Vertical Translations, Horizontal Translations, Vertical Stretching and Compressing, Horizontal Stretching and Compressing, Reflecting*

3. 1.1 Intuitive introduction to Limits- A Real-Life Example, Intuitive Definition of a Limit, One-Sided Limits, Using Graphing Utilities to Evaluate Limits
4. 1.2 Techniques for finding Limits- Computing Limits Using the Laws of Limits, Limits of Polynomial and Rational Functions, Limits of Trigonometric Functions, The Squeeze Theorem.
5. 1.3 Precise Definition of a Limit- $\varepsilon - \delta\ definition$, A Geometric Interpretation, Some illustrative examples
6. 1.4 Continuous Functions- Continuity at a Number, Continuity at an Endpoint, Continuity on an Interval, Continuity of Composite Functions, Intermediate Value Theorem
7. 1.5 Tangent Lines and Rate of change- An Intuitive Look, Estimating the Rate of Change of a Function from Its Graph, More Examples Involving Rates of Change, Defining a Tangent Line, Tangent Lines, Secant Lines, and Rates of Change
8. 2.1 The Derivatives- *Definition*, Using the Derivative to Describe the Motion of the Maglev, Differentiation, Using the Graph of f to Sketch the Graph of f' Differentiability, Differentiability and Continuity

9. 2.4 The role of derivative in the real world- Motion Along a Line, Marginal Functions in Economics

10. 2.9 Differentials and Linear Approximations- increments, Differentials, Error Estimates, Linear

Approximations, Error in Approximating Δy by dy

Module 2 **17 Hours**

(Applications of the Derivative)

1. 3.1 Extrema of Functions -Absolute Extrema of Functions, Relative Extrema of Functions, Fermat's Theorem, Finding the Extreme Values of a Continuous Function on a Closed Interval, An Optimization Problem
2. 3.2 The Mean Value Theorem- Rolle's Theorem, The Mean Value Theorem, Some Consequences of the Mean Value Theorem, Determining the Number of Zeros of a Function
3. 3.3 Increasing and Decreasing Functions- definition, inferring the behavior of function from sign of derivative, Finding the Relative Extrema of a Function, first derivative test
4. 3.4 Concavity and Inflection points- Concavity, Inflection Points, The Second Derivative Test, The Roles of f' and f" in Determining the Shape of a Graph
5. 3.5 Limits involving Infinity; Asymptotes- Infinite Limits, Vertical Asymptotes, Limits at infinity, Horizontal Asymptotes, Infinite Limits at infinity, Precise Definitions
6. 3.6 Curve Sketching-The Graph of a Function, Guide to Curve Sketching, Slant Asymptotes, Finding Relative Extrema Using a Graphing Utility
7. 3.7 Optimization Problems – guidelines for finding absolute extrema, Formulating Optimization Problems- application involving several real-life problems

Module 3 **14 Hours**

(Integration)

1. 4.1 Anti derivatives, Indefinite integrals, Basic Rules of Integration, a few basic integration formulas and rules of integration, Differential Equations, Initial Value Problems
2. 4.2 Area- An Intuitive Look, The Area Problem, Defining the Area of the Region Under the Graph of a Function-technique of approximation ['Sigma Notation' and 'Summation Formulas' Omitted] An Intuitive Look at Area (Continued), Defining the Area of the Region Under the Graph of a Function-precise definition, Area and Distance
3. 4.4 The Definite Integral- Definition of the Definite Integral, Geometric Interpretation of the Definite Integral, The Definite Integral and Displacement, Properties of the Definite Integral , More General Definition of the Definite Integral
4. 4.5 The Fundamental Theorem of Calculus- How Are Differentiation and Integration Related?, The Mean Value Theorem for Definite Integrals, The Fundamental Theorem of Calculus: Part I, inverse relationship between differentiation and integration, Fundamental Theorem of Calculus: Part 2, Evaluating Definite Integrals Using Substitution, Definite Integrals of Odd and Even Functions, The Definite Integral as a Measure of Net Change

Module 4 **13 Hours**

(Applications of Definite Integral)

1. 5.1 Areas between Curves- A Real Life Interpretation, The Area Between Two Curves, Integrating with Respect to y-adapting to the shape of the region, What Happens When the Curves Intertwine?
2. 5.2 Volume – Solids of revolution, Volume by Disk Method, Region revolved about the x-axis, Region revolved about the y-axis, Volume by the Method of Cross Sections [‘ Washer Method’ omitted]
3. 5.4 Arc Length and Areas of surfaces of revolution- Definition of Arc Length, Length of a Smooth Curve, arc length formula, The Arc Length Function, arc length differentials, Surfaces of Revolution, surface area as surface of revolution,
4. 5.5 Work-Work Done by a Constant Force, Work Done by a Variable Force, Hook’s Law, Moving non rigid matter, Work done by an expanding gas
5. 5.7 Moments and Center of Mass- Measures of Mass, Center of Mass of a System on a Line, Center of Mass of a System in the Plane, Center of Mass of Laminas [up to and including Example 3; rest of the section omitted]

References:

1. Joel Hass, Christopher Heil & Maurice D. Weir : Thomas’ Calculus(14/e) *Pearson (2018) ISBN 0134438981*
2. Robert A Adams & Christopher Essex : Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN:* 0321877403
3. Jon Rogawski & Colin Adams : Calculus *Early Transcendentals* (3/e) *W. H. Freeman and Company(2015) ISBN: 1319116450*
4. Anton, Bivens & Davis : Calculus *Early Transcendentals* (11/e) *John Wiley & Sons, Inc.(2016) ISBN: 1118883764*
5. James Stewart : Calculus (8/e) *Brooks/Cole Cengage Learning(2016) ISBN: 978- 1-285-74062-1*
6. Jerrold Marsden & Alan Weinstein : Calculus I and II (2/e*) Springer Verlag NY (1985) ISBN 0-387-90974-5 : ISBN 0-387-90975-3*

Text:

1. Calculus: Soo T Tan *Brooks/Cole*, *Cengage Learning (2010) ISBN: 978-0-534-46579-7*

SEMESTER 3

MTS3 B 03 CALCULUS OF SINGLE VARIABLE-2

Number of Credits: 4

Contact Hours per week: 5

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 **20 Hours**

(The Transcendental Functions)

1. 6.1 The Natural logarithmic function- definition, The Derivative of $ln\ x$, Laws of Logarithms, The Graph of the Natural Logarithmic Function, The Derivatives of Logarithmic Functions, Logarithmic Differentiation, Integration Involving Logarithmic Functions
2. 6.2 Inverse Functions-The Inverse of a Function, The Graphs of Inverse Functions, Which Functions have Inverses?, Finding the Inverse of a Function, Continuity and Differentiability of Inverse Functions.
3. 6.3 Exponential Functions- The number e , Defining the Natural Exponential Function, properties, The Laws of Exponents, The Derivatives of Exponential Functions, Integration of the Natural Exponential Function
4. 6.4 General Exponential and Logarithmic Functions - Exponential Functions with Base a, laws of exponents, The Derivatives of ax,au, Graphs of y= ax, integrating ax , Logarithmic Functions with Base a, change of base formula, The Power Rule (General Form), The Derivatives of Logarithmic Functions with Base a , The Definition of the Number e as a Limit ['Compound Interest' omitted]
5. 6 . 5 Inverse trigonometric functions- definition, graph, inverse properties, Derivative of inverse trigonometric functions, Integration Involving Inverse Trigonometric Functions
6. 6.6 Hyperbolic functions- The Graphs of the Hyperbolic Functions, Hyperbolic Identities, Derivatives and Integrals of Hyperbolic Functions, Inverse Hyperbolic Functions, representation in terms of logarithmic function, Derivatives of Inverse Hyperbolic Functions, An Application
7. 6.7 Indeterminate forms and L-Hopital rule- *motivation*, The Indeterminate Forms $\frac{0}{0}$ and $\frac{\infty}{\infty}$ Indeterminate forms $\infty - \infty$ and $0.\infty$. The indeterminate forms 0^0, ∞^0 and 1^∞

Module 2 **20 Hours**

(Infinite Sequences and Series)

1. 7.6 Improper integrals – definition, Infinite Intervals of Integration, Improper Integrals with Infinite Discontinuities, A Comparison Test for Improper Integrals
2. 9.1 Sequences- definition, recursive definition, Limit of a Sequence, limit laws, squeeze theorem, Bounded Monotonic Sequences, definition, monotone convergence theorem (only statement; its proof omitted)
3. 9.2 Series- defining the sum, convergence and divergence, Geometric Series, The Harmonic Series, The Divergence Test, Properties of Convergent Series
4. 9.3 The Integral Test – investigation of convergence, integral test, The p- Series, its convergence and divergence
5. 9.4 The Comparison Test- test series, The Comparison Test, The Limit Comparison Test
6. 9.5 Alternating Series- definition, the alternating series test, its proof, examples,
7. Approximating the Sum of an Alternating Series by Sn
8. 9.6 Absolute Convergence- definition, conditionally convergent, The Ratio Test, The Root Test, Summary of Tests for Convergence and Divergence of Series, Rearrangement of Series

Module 3 **20 Hours**

1. 9.7 Power Series- definition, Interval of Convergence, radius of convergence, Differentiation and Integration of Power Series
2. 9.8 Taylor and Maclaurin Series- definition, Taylor and Maclaurin series of functions, Techniques for Finding Taylor Series
3. 10.2 Plane Curves and Parametric Equations- Why We Use Parametric Equations, Sketching Curves Defined by Parametric Equations
4. 10.3 The Calculus of parametric equations- Tangent Lines to Curves Defined by Parametric Equations, Horizontal and Vertical Tangents, Finding $\frac{d^2y}{dx^2}$ from Parametric Equations, The Length of a Smooth Curve, The Area of a Surface of Revolution.
5. 10.4 Polar coordinate-The Polar Coordinate System, Relationship Between Polar and Rectangular Coordinates, Graphs of Polar Equations, Symmetry, Tangent Lines to Graphs of Polar Equations
6. 10.5 Areas and Arc Lengths in polar coordinates-Areas in Polar Coordinates, area bounded by polar curves, Area Bounded by Two Graphs, Arc Length in Polar Coordinates, Area of a Surface of Revolution, Points of Intersection of Graphs in Polar Coordinates

Module 4 **20 Hours**

1. 11.5 Lines and Planes in Space-Equations of Lines in Space, parametric equation, symmetric

equation of a line, Equations of Planes in Space, standard equation, Parallel and Orthogonal Planes, The Angle Between Two Planes, The Distance Between a Point and a Plane

2. 11.6 Surfaces in Space- Traces, Cylinders, Quadric Surfaces, Ellipsoids, Hyperboloids of One Sheet, Hyperboloids of Two Sheets, Cones, Paraboloids, Hyperbolic Paraboloids
3. 11.7 Cylindrical and Spherical Coordinates-The Cylindrical Coordinate System, converting cylindrical to rectangular and vice versa, The Spherical Coordinate System, converting spherical to rectangular and vice versa,
4. 12.1 Vector Valued functions and Space Curves- definition of vector function, Curves Defined by Vector Functions, [‘Example 7’ omitted] Limits and Continuity
5. 12.2 Differentiation and Integration of Vector-Valued Function- The Derivative of a Vector Function, Higher-Order Derivatives, Rules of Differentiation, Integration of Vector Functions,
6. 12.3 Arc length and Curvature- Arc Length of a space curve, Smooth Curves, Arc Length Parameter, arc length function, Curvature, formula for #inding curvature, Radius of Curvature,
7. 12.4 Velocity and Acceleration- Velocity, Acceleration, and Speed; Motion of a Projectile
8. 12.5 Tangential and Normal Components of Acceleration- The Unit Normal, principal unit normal vector, Tangential and Normal Components of Acceleration [The subsections ‘ Kepler’s Laws of Planetary Motion ’, and ’ Derivation of Kepler’s First Law’ omitted]

References:

1. Joel Hass, Christopher Heil & Maurice D. Weir : Thomas’ Calculus (14/ e) *Pearson(2018) ISBN 0134438981*
2. Robert A Adams & Christopher Essex : Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN:* 0321877403
3. Jon Rogawski & Colin Adams : Calculus *Early Transcendentals* (3/e) W.H. Freeman and Company(2015) *ISBN: 1319116450*
4. Anton, Bivens & Davis : Calculus *Early Transcendentals* (11/e) *John Wiley & Sons, Inc.(2016) ISBN: 1118883764*
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1. Calculus: Soo T Tan *Brooks/Cole*, *Cengage Learning (2010) ISBN: 978-0-534-46579-7*

SEMESTER 4

MTS4 B04 LINEAR ALGEBRA

Number of Credits: 4

Contact Hours per week: 5

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 **17 Hours**

Systems of Linear Equations & Matrices

1. 1.1 Introduction to Systems of Linear Equations- *linear equation in n variables, linear system of m equations in n variables, solution,* Linear Systems in Two and Three Unknowns, *solution by geometric analysis*, *consistent and inconsistent systems, linear system with no, one, and infinite number of solutions*, augmented matrix and elementary row operations
2. 1.2 Gaussian elimination - Considerations in Solving Linear Systems, Echelon Forms, *reduced row echelon form,* Elimination Methods, *Gauss– Jordan elimination, Gaussian elimination,* Homogeneous Linear Systems, *Free Variables, Free Variable Theorem for Homogeneous Systems,* Gaussian Elimination and Back- Substitution, Some Facts about Echelon Forms
3. 1.3 Matrices and Matrix operations- Matrix Notation and Terminology, *row vector, column vector, square matrix of order n, Operations on Matrices,* Partitioned Matrices, Matrix Multiplication by Columns and by Rows, Matrix Products as Linear Combinations, *linear combination* of column vectors, Column-Row Expansion, Matrix Form of a Linear System, Transpose of a Matrix, Trace of a Matrix
4. 1.4 Inverses and algebraic properties of matrices- *Properties of Matrix Addition and Scalar Multiplication, Properties of Matrix Multiplication, Zero Matrices and Properties, Identity Matrices, Inverse of a Matrix, Properties of Inverses, Solution of a Linear System by Matrix Inversion*, Powers of a Matrix, Matrix Polynomials, *Properties of the Transpose*
5. 1.5 Elementary matrices and a method for finding *A -row equivalence*, *elementary matrix, Row Operations by Matrix Multiplication, invertibility of elementary matrices, invertibility and equivalent statements, A Method for Inverting Matrices, Inversion Algorithm, illustrations.*
6. 1.6 More on linear systems and invertible matrices - Number of Solutions of a Linear System, Solving Linear Systems by Matrix Inversion, *Linear Systems with a Common Coefficient Matrix, Properties of Invertible Matrices, equivalent statements for unique solution of $Ax = b$, determining consistency*

7. 1.7 Diagonal, Triangular and Symmetric Matrices-*Diagonal Matrices, Inverses and Powers of Diagonal Matrices, Triangular Matrices. Properties of Triangular Matrices, Symmetric Matrices, algebraic properties of symmetric matrices, Invertibility of Symmetric Matrices*
8. 1.8 Matrix transformation- *definition*, Properties of Matrix Transformations, *standard matrix,* A Procedure for Finding Standard Matrices
9. 2.1 Determinants by cofactor expansion- *minors, cofactors, cofactor expansion, Definition of a General Determinant, A Useful Technique for Evaluating 2× 2 and 3 × 3 Determinants*
10. 2.2 Evaluating determinants by row reduction- a *few basic theorems, elementary row operations and determinant, determinant of elementary matrices, determinant by row reduction*

Module 2 **18 Hours**

General Vector Spaces

1. 4.1 Real vector space - *Vector Space Axioms, examples, Some Properties of Vectors*
2. 4.2 Subspaces- *definition, criteria for a subset to be a subspace, examples, Building Subspaces, linear combination, spanning, Solution Spaces of Homogeneous Systems as subspace, The Linear Transformation Viewpoint, kernel, different set of vectors spanning the subspace.*
3. 4.3 Linear Independence- *Linear Independence and Dependence, illustrations, A Geometric Interpretation of Linear Independence, Wronskian, linear independence using Wronskian*
4. 4.4 Coordinates and basis-*Coordinate Systems in Linear Algebra, Basis for a Vector Space, finite and infinite dimensional vector spaces, illustrations, Coordinates Relative to a Basis, Uniqueness of Basis Representation*
5. 4.5 Dimension- *Number of Vectors in a Basis*, dimension, *Some Fundamental Theorems, dimension of subspaces,*

Module 3 **22 Hours**

1. 4.6 Change of basis -*Coordinate Maps, Change of Basis, Transition Matrices, Invertibility of Transition Matrices, An Efficient Method for Computing Transition Matrices for $\mathbb{R}^n$, Transition to the Standard Basis for $\mathbb{R}^n$*
2. 4.7 Row space, Column space and Null space- vector spaces associated with matrices, consistency of linear system, *Bases for Row Spaces, Column Spaces, and Null Spaces, basis from* row echelon form, *Basis for the Column Space of a Matrix, row equivalent matrices and relationship between basis for column space, Bases Formed from Row and Column Vectors of a Matrix*
3. 4.8 Rank Nullity and Fundamental matrix spaces- equality of dimensions of row and column spaces, *Rank and Nullity,* Dimension Theorem for Matrices**,** *The Fundamental Spaces of a Matrix, rank of a matrix and its transpose, A Geometric Link Between the Fundamental Spaces, orthogonal*

complement, invertibility and equivalent statements, Applications of Rank, Overdetermined and Underdetermined Systems

4. 4.9 Basic matrix transformations in R^2 and R^3 - *Reflection Operators, Projection Operators, Rotation Operators, Rotations in $\mathbb{R}^3$ Dilations and Contractions, Expansions and Compressions, Shears, Orthogonal Projections onto Lines Through the Origin, Reflections About Lines Through the Origin*

5. 4.10 Properties of matrix transformation- *Compositions of Matrix Transformations, One-to-One Matrix Transformations, Kernel and Range, fundamental relationship between invertibility of a matrix and its matrix transformation, Inverse of a One-to-One Matrix Operator*

Module 4 **23 Hours**

1. 4.11 Geometry of matrix operators-Transformations of Regions, Images of Lines Under Matrix Operators, Geometry of Invertible Matrix Operators, Elementary matrix and its matrix transformation, consequence
2. 5.1 Eigen values and Eigen Vectors- definition, Computing Eigenvalues and Eigenvectors, characteristic equation, alternative ways of describing eigen values, Finding Eigenvectors and Bases for Eigenspaces, Eigenvalues and Invertibility, Eigenvalues of General Linear Transformations,
3. 5.2 Diagonalization- The Matrix Diagonalization Problem, linear independence of eigen vectors and diagonalizability, Procedure for Diagonalizing a Matrix, Eigenvalues of Powers of a Matrix, Computing *Powers of a Matrix, Geometric and Algebraic Multiplicity*

4. 6.1 Inner Product – definition of General inner product, Euclidean inner product (or the standard inner product) on $\mathbb{R}n$, norm of a vector, properties (up to and including theorem 6.1.1), a few examples (only example7 and example 10) [rest of the section omitted]

5. 6.2 Angle and orthogonality in Inner product spaces- only the definition of orthogonality in a real inner product space (to be motivated by the relation in the definition (3) of section 3.2) and examples (2),(3) and(4)

6. 6.3 Gram–Schmidt Process- definition of Orthogonal and Orthonormal Sets, examples, linear independence of orthogonal set, orthonormal basis, Coordinates Relative to Orthonormal Bases [‘Orthogonal Projections’ omitted] The Gram–Schmidt Process [only statement of Theorem 6.3.5 and the step by step construction technique are required; derivation omitted], illustrations- examples 8 and 9, Extending Orthonormal Sets to Orthonormal Bases [rest of the section omitted]

7. 7.1 Orthogonal Matrices- definition, characterization of orthogonal matrices, properties of

orthogonal matrices, Orthogonal Matrices as Linear Operators, a geometric interpretation [rest of the section omitted]

8. 7.2 Orthogonal Diagonalization- The Orthogonal Diagonalization Problem, Conditions for Orthogonal Diagonalizability, Properties of Symmetric Matrices, Procedure for Orthogonally Diagonalizing an $n \times n$ Symmetric Matrix, Spectral Decomposition (upto and including example2) [rest of the section omitted]

References:

1. Jim DeFranza, Daniel Gagliardi: Introduction to Linear Algebra with Applications *Waveland Press, Inc (2015) ISBN: 1-4786-2777-8*
2. Otto Bretscher: Linear Algebra with Applications(5/e) Pearson Education, Inc (2013) ISBN: 0-321-79697-7
3. Ron Larson, Edwards, David C Falvo : Elementary Linear Algebra(6/e) *Houghton Mifflin Harcourt Publishing Company(2009) ISBN: 0-618-78376-8*
4. David C. Lay, Steven R. Lay, Judi J. McDonald: Linear Algebra and its Application (5/e) *Pearson Education, Inc (2016) ISBN: 0-321-98238-X*
5. Martin Anthony, Michele Harvey: Linear Algebra: Concepts and Methods *Cambridge University Press (2012) ISBN:978-0-521-27948-2*
6. Jeffrey Holt: Linear Algebra with Applications *W. H. Freeman and Company (2013) ISBN: 0-7167-8667-2*

Text:

1. Elementary Linear Algebra: Application Version(11/e): Howard Anton & Chris Rorres *Wiley (2014) ISBN 978-1-118-43441-3*

SEMESTER 5

MTS5 B05 ABSTRACT ALGEBRA

Number of Credits: 4

Contact Hours per week: 5

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 **15 Hours**

1. 1.4: Integers modulo n - congruence class modulo n, addition and multiplication, divisor of zero, multiplicative inverse
2. 2.2: Equivalence relations-basic idea, definition, equivalence class, factor set, partition and equivalence relation, examples and illustrations
3. 2.3: Permutations- definition, cycles, product of cycles, permutation as product of disjoint cycles, order of cycles, transposition, even and odd transpositions

Module 2 **25 Hours**

1. 3.1: Definition of Group-binary operation, uniqueness of identity and inverse, definition and examples of groups, properties, Abelian group, finite and infinite groups, general linear groups
2. 3.2: Subgroups-the notion of subgroup, examples, conditions for a subgroup, cyclic subgroups, order of an element, Lagrange theorem, Euler's theorem 27 Page 29 of 100
3. 3.3: Constructing examples- groups with order up to 6, multiplication table, product of subgroups, direct products, Klein four group as direct product, subgroup generated by a subset
4. 3.4: Isomorphism – definition, consequences, structural properties, method of showing that groups are not isomorphic, isomorphic and non isomorphic groups.

Module 3 **25 Hours**

1. 3.5: Cyclic groups- subgroups of cyclic groups, characterization, generators of a finite cyclic group, structure theorem for finite cyclic group, exponent of a group, characterization of cyclic groups among finite abelian groups.

2. 3.6: Permutation groups- definition, Cayley's theorem, rigid motions of n-gons, dihedral group, alternating group
3. 3.7: Homomorphism - basic idea, examples, definition, properties, kernel, normal subgroups, subgroups related via homomorphism
4. 3.8: Cosets- left and right cosets, normal subgroups and factor groups, fundamental homomorphism theorem, simple groups, examples and illustrations of concepts

Module 4 **15 Hours**

1. 7.1: (Structure of Groups) Isomorphism theorems; Automorphism- first isomorphism theorem, second isomorphism theorem, inner automorphism
2. 5.1: Commutative Rings ; Integral Domains- definition, examples, subring, criteria to be a subring, divisor of zero, integral domain, finite integral domain

References:

1. Joseph A. Gallian : Contemporary Abstract Algebra(9/e) Cengage Learning, Boston(2017) ISBN: 978-1-305-65796-0
2. John B Fraleigh : A First Course in Abstract Algebra(7/e) Pearson Education LPE (2003) ISBN 978-81-7758-900-9
3. David Steven Dimmit, Richard M. Foote: Abstract Algebra(3/e) Wiley, (2004) ISBN: 8126532289
4. Linda Gilbert and Jimmie Gilbert: Elements of Modern Algebra (8/e) Cengage Learning, Stamford(2015) ISBN: 1-285-46323-4
5. John R. Durbin : Modern Algebra: An Introduction(6/e) Wiley(2015) ISBN: 1118117611
6. Jeffrey Bergen: A Concrete Approach to Abstract Algebra- From the integers to Insolvability of Quintic Academic Pres [Elsevier](2010)ISBN: 978-0- 12-374941-3

Text:

1. Abstract Algebra(3/e): John A Beachy and William D Blair Waveland Press, Inc.(2006) ISBN: 1-57766-443-4

MTS5 B06 BASIC ANALYSIS

Number of Credits: 4

Contact Hours per week: 5

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 (Text 1) 20 Hours

1. 1.3 Finite and Infinite Sets - definition, countable sets, denumerability of $\mathbb{Q}$, union of countable sets, cantor's theorem
2. 2.1 The Algebraic and Order Properties of $\mathbb{R}$- algebraic properties, basic results, rational and irrational numbers, irrationality of $\sqrt{2}$, Order properties, arithmetic-geometric inequality, Bernoulli's Inequality
3. 2.2 Absolute Value and the Real Line- definition, basic results, Triangle Inequality, The real line, ε-neighborhood
4. 2.3 The Completeness Property of $\mathbb{R}$- Suprema and Infima, alternate formulations for the supremum, The Completeness Property

Module 2 (Text 1) 21 Hours

1. 2.4 Applications of the Supremum Property- The Archimedean Property, various consequences, Existence of $\sqrt{2}$, Density of Rational Numbers in $\mathbb{R}$, The Density Theorem, density of irrationals
2. 2.5 Intervals -definition, Characterization of Intervals, Nested Intervals, Nested Intervals Property, The Uncountability of $\mathbb{R}$, [binary, decimal and periodic representations omitted] Cantor's Second Proof.
3. 3.1 Sequences and Their Limits- definitions, convergent and divergent sequences, Tails of Sequences, Examples
4. 3.2 Limit Theorems- sum, difference, product and quotients of sequences, Squeeze Theorem, ratio test for convergence
5. 3.3 Monotone Sequences -definition, monotone convergence theorem, divergence of harmonic series, calculation of square root, Euler's number

Module 3 (Text 1) 18 Hours

1. 3.4 Subsequences and the Bolzano-Weierstrass Theorem- definition, limit of

subsequences, divergence criteria using subsequence, The Existence of Monotone Subsequences, monotone subsequence theorem, The Bolzano-Weierstrass Theorem, Limit Superior and Limit Inferior

2. 3.5 The Cauchy Criterion- Cauchy sequence, Cauchy Convergence Criterion, applications, contractive sequence
3. 3.6 Properly divergent sequences- definition, examples, properly divergent monotone sequences, ‘‘comparison theorem’’ , ‘‘limit comparisontheorem’’
4. 11.1 Open and Closed sets in $\mathbb{R}$- neighborhood, open sets, closed sets, open set properties, closed set properties, Characterization of Closed Sets, cluster point, Characterization of Open Sets, The Cantor Set, properties

Module 4 (Text 2) **21 Hours**

1. 1.1 Complex numbers and their properties- definition, arithmetic operations, conjugate, inverses, reciprocal
2. 1.2 Complex Plane- vector representation, modulus, properties, triangle inequality
3. 1.3 Polar form of complex numbers- polar representation, principal argument, multiplication and division, argument of product and quotient, integer powers, de Moivre’s formula.
4. 1.4 Powers and roots- roots, principal n^{th} root
5. 1.5 Sets of points in the complex plane- circles, disks and neighborhoods, open sets, annulus, domains, regions, bounded sets
6. 2.1 Complex Functions- definition, real and imaginary parts of complex function, complex exponential function, exponential form of a complex number, Polar Coordinates
7. 2.2 Complex Functions as mappings- complex mapping, illustrations, Parametric curves in complex planes, common parametric curves, image of parametric curves under complex mapping [The subsection ‘Use of Computers’ omitted]
8. 2.3 Linear Mappings- Translations, Rotations, Magnifications, general linear mapping, image of geometric shapes under linear map
9. 2.4 Special Power functions- The power function z^n, The power function $z^{\frac{1}{n}}$ principal square root function, Inverse Functions, multiple valued functions

References:

1. Charles G. Denlinger: Elements of Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2011) ISBN:0-7637-7947-4 [Indian edition: ISBN- 9380853157]*

2. David Alexander Brannan: A First Course in Mathematical Analysis *Cambridge University Press, US (2006) ISBN: 9780521684248*

3. John M. Howie: Real Analysis *Springer Science & Business Media (2012) [Springer Undergraduate Mathematics Series] ISBN: 1447103416*

4. James S. Howland: Basic Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2010) ISBN:0-7637-7318-2*

5. James Ward Brown, Ruel Vance Churchill: Complex variables and applications(8/e) *McGraw-Hill Higher Education, (2009) ISBN: 0073051942*

6. Alan Jeffrey: Complex Analysis and Applications(2/e) *Chapman and Hall/ CRC Taylor Francis Group (2006) ISBN:978-1-58488-553-5*

7. Saminathan Ponnusamy, Herb Silverman: Complex Variables with Applications *Birkhauser Boston (2006) ISBN:0-8176-4457-4*

8. Terrace Tao: Analysis I & II (3/e) *TRIM 37 Springer Science+Business Media Singapore 2016; Hindustan book agency (2015) ISBN 978-981-10-1789-6 (eBook) & ISBN 978-981-10-1804-6 (eBook)*

9. Ajith Kumar & S Kumaresan: A Basic Course in Real Analysis *CRC Press, Taylor & Francis Group (2014) ISBN: 978-1- 4822-1638-7 (eBook - PDF)*

10. Hugo D Junghenn: A Course in Real Analysis *CRC Press, Taylor & Francis Group (2015) ISBN: 978-1-4822-1928-9 (eBook - PDF)*

Text:

1. Introduction to Real Analysis(4/e): Robert G Bartle, Donald R Sherbert *John Wiley & Sons (2011) ISBN 978-0-471-43331-6*

2. Complex Analysis A First Course with Applications (3/e): Dennis Zill & Patric Shanahan *Jones and Bartlett Learning (2015) ISBN:1-4496-9461-6*

MTS5 B07 NUMERICAL ANALYSIS

Number of Credits: 3

Contact Hours per week: 4

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **28 Hours**

Solutions of Equations in One Variable

Note: Students should be familiar with concepts and definitions such as 'round off error', rate of convergencies. discussed in sections 1.2 and 1.3

Introduction

1. 2.1: The Bisection Method
2. 2.2: Fixed-Point Iteration
3. 2.3: Newton's Method and Its Extensions- *Newton's Method (Newton- Raphson method), Convergence using Newton's Method, The Secant Method, The Method of False Position*
4. 2.4 Error Analysis for Iterative Methods- Order of Convergence, *linear and quadratic convergence,* Multiple Roots, *Modified Newton's method for faster convergence [Algorithms are omitted]*

Introduction

1. 3.1: Interpolation and the Lagrange Polynomial- *motivation*, Lagrange Interpolating Polynomials, *error bound*
2. 3.2: Data Approximation and Neville's Method- *motivation*, Neville's Method, *recursive method to generate Lagrange polynomial approximations*.
3. 3.3: Divided Differences- k^{th} *divided difference*, *Newton's divided difference formula,* Forward Differences, Newton Forward-Difference Formula, Backward Differences, Newton Backward–Difference Formula, Centered Differences, *Stirling's formula. [Algorithms are omitted]*

Module 2 **18 Hours**

Numerical Differentiation and Integration

Introduction

1. 4.1: Numerical Differentiation- *approximation of first derivative by forward difference formula, backward difference formula, Three-Point Formulas, Three-Point Endpoint Formula, Three-Point Midpoint Formula [Five-Point Formulas, Five-Point Endpoint Formula, Five-Point Midpoint Formula omitted]* Second Derivative Midpoint Formula *to approximate second derivative,* Round-Off Error Instability
2. 4.3: Elements of Numerical Integration-*numerical quadrature,* The Trapezoidal Rule, Simpson's

Rule, Measuring Precision, Closed Newton- Cotes Formulas, Simpson's Three-Eighths rule, Open Newton-Cotes Formulas

3. 4.4: Composite Numerical Integration-*composite Simpson's rule, composite trapezoidal rule, composite midpoint rule, round off error stability*
4. 4.7: Gaussian Quadrature-*motivation*, Legendre Polynomial, Gaussian Quadrature on Arbitrary Intervals

   [Algorithms are omitted]

Module 3 **18 Hours**

Initial-Value Problems for Ordinary Differential Equations

Introduction

1. 5.1 The Elementary Theory of Initial-Value Problems
2. 5.2 Euler's Method- *derivation using Taylor formula,* Error bounds for Euler Method
3. 5.3 Higher-Order Taylor Methods- *local truncation error*, *Taylor method of order n and order of local truncation error*
4. 5.4 Runge-Kutta Methods- *only* Mid Point Method, Modi^ied Euler's Method and Runge-Kutta Method of Order Four are required. *[derivation of formula omitted in each case]*
5. 5.6 Multistep Methods- *basic idea, de*ﬁ*nition*, Adams-Bashforth Two-Step Explicit Method, Adams-Bashforth Three-Step Explicit Method, Adams- Bashforth Four-Step Explicit Method, Adams-Moulton Two-Step Implicit Method, Adams-Moulton Three-Step Implicit Method, Adams-Moult on Four-Step Implicit Method, Predictor-Corrector Methods *[derivation of formula omitted in each case]* [Algorithms are omitted]

References:

1. Kendall E. Atkinson, Weimin Han: Elementary Numerical Analysis(3/e) *John Wiley & Sons (2004) ISBN:0-471-43337-3[Indian Edition by Wiley India ISBN: 978-81-265-0802-0]*
2. James F. Epperson: An Introduction to Numerical Methods and Analysis(2/e) *John Wiley & Sons (2013) ISBN: 978-1-118-36759-9*
3. Timothy Sauer: Numerical Analysis(2/e) *Pearson (2012) ISBN: 0-321- 78367-0*
4. S S Sastri: Introductory Methods of Numerical Analysis(5/e) *PHI Learning Pvt. Ltd. (2012) ISBN:978-81-203-4592-8*
5. Ward Cheney,David Kincaid : Numerical Mathematics and Computing (6/e) *Thomson Brooks/Cole (2008) ISBN: 495-11475-8*

Text:

1. Numerical Analysis (10/e): *Richard L. Burden, J Douglas Faires, Annette M. Burden Brooks Cole Cengage Learning (2016) ISBN:978-1-305-25366-7*

MTS5 B 08 LINEAR PROGRAMMING

Number of Credits: 3

Contact Hours per week: 3

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **16 Hours**

Chapter 1

Geometric Linear Programming: Profit Maximization and Cost Minimization, *typical motivating examples*, *mathematical formulation*, Canonical Forms for Linear Programming Problems, *objective functions, constraint set, feasible solution, optimal solution* , Polyhedral Convex Sets, *convex set, extreme point*, *theorems asserting existence of optimal solutions,* The Two Examples Revisited, *graphical solutions to the problems*, A Geometric Method for Linear Programming, *the difficulty in the method*, Concluding Remarks

Chapter 2

The Simplex Algorithm:- Canonical Slack Forms for Linear Programming Problems; Tucker Tableaus, *slack variables, Tucker tableaus*, *independent variables* or *non basic variables, dependent variables* or *basic variables,* An Example: Profit Maximization, *method of solving a typical canonical maximization problem*, The Pivot Transformation, *The Pivot Transformation for Maximum and Minimum Tableaus,* An Example: Cost Minimization, *method of solving a typical canonical minimization problem*, The Simplex Algorithm for Maximum Basic Feasible Tableaus, The Simplex Algorithm for Maximum Tableaus, Negative Transposition; The Simplex Algorithm for Minimum Tableaus, Cycling, Simplex Algorithm Anti cycling Rules, Concluding Remarks

Module 2 **14 Hours**

Chapter 3

Noncanonical Linear Programming Problems: - Unconstrained Variables, Equations of Constraint, Concluding Remarks

Chapter 4

Duality Theory: - Duality in Canonical Tableaus, The Dual Simplex Algorithm, *The Dual Simplex Algorithm for Minimum Tableaus, The Dual Simplex Algorithm for Maximum Tableaus,* Matrix Formulation of Canonical Tableaus, The Duality Equation, Duality in Noncanonical Tableaus, Concluding Remarks

Module 3 **18 Hours**

Chapter 5

Matrix Games:- An Example; Two-Person Zero-Sum Matrix Games, Domination in a Matrix Game, Linear Programming Formulation of Matrix Games, The Von Neumann Minimax Theorem, The Example Revisited, Two More Examples, Concluding Remarks

Chapter 6

Transportation and Assignment Problems: - The Balanced Transportation Problem, The Vogel Advanced-Start Method (VAM), The Transportation Algorithm, Another Example, Unbalanced Transportation Problems, The Assignment Problem, *The Hungarian Algorithm,* Concluding Remarks, *The Minimum-Entry Method*, *The Northwest-Corner Method*

References:

1. RobertJ.Vanderbei: Linear Programming: Foundations and Extensions (2/e) Springer Science+Business Media LLC (2001) ISBN: 978-1-4757- 5664-7
2. Frederick S Hiller, Gerald J Lieberman: Introduction to Operation Research(10/e) *McGraw-Hill Education, 2 Penn Plaza, New York (2015) ISBN: 978-0-07-352345-3*
3. Paul R. Thie, G. E. Keough: An Introduction to Linear Programming and Game Theory(3/e) *John Wiley and Sons,Ins.(2008)ISBN: 978-0-470-23286-6*

4 Louis Brickman: Mathematical Introduction to Linear Programming and Game Theory *UTM,Springer Verlag,NY(1989)ISBN:0-387-96931-4*

5. Jiri Matoušek, Bernd Gartner: Understanding and Using Linear Programming *Universitext*, *Springer-Verlag Berlin Heidelberg (2007) ISBN: 978-3-540-30697-9*

Text:

Linear Programming and Its Applications: James K. Strayer *Under- Graduate Texts in Mathematics Springer (1989) ISBN: 978-1-4612-6982-3*

MTS5 B 09 INTRODUCTION TO GEOMERY AND THEORY OF EQUATIONS

Number of Credits: 3

Contact Hours per week: 3

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **20 Hours**

Conics

1. 1.1.1: Conic Section

2. 1.1.3: Focus-Directrix Definition of the Non-Degenerate Conics- *definition*, *parabola in standard form, ellipse in standard form, hyperbola in standard form,* Rectangular Hyperbola, Polar Equation of a Conic
3. 1.1.4: Focal Distance Properties of Ellipse and Hyperbola-*Sum of Focal Distances of Ellipse, Difference of Focal Distances of Hyperbola,*
4. 1.2: Properties of Conics**-** Tangents, *equation of tangents to ellipse, hyperbola, and parabola*, *polar of a point w.r.t. unit circle*, *normal*, Reflections, *The Reflection Law,* Reflection Property of the Ellipse, Reflection Property of the Hyperbola, Reflection Property of the Parabola, Conics as envelopes of tangent families
5. 1.3: Recognizing Conics- *equation of conic in general form, identifying a conic*

Affine Geometry

1. 2.1: Geometry and Transformations - What is Euclidean Geometry? *Isometry, Euclidean properties, Euclidean transformation*, Euclidean-Congruence
2. 2.2 Af^ ine Transformations and Parallel Projections- Af^ine Transformations, *Basic Properties of Affine Transformations*, Parallel Projections, *Basic Properties of Parallel Projections*, Af^ine Geometry, *Midpoint Theorem, Conjugate Diameters Theorem, Affine Transformations and Parallel Projections, affine transformations as composite of two parallel projections*
3. 2.3: Properties of Af^ine Transformations-Images of Sets Under Af^ine Transformations, The Fundamental Theorem of Af^ine Geometry, Proofs of the Basic Properties of Af^ine Transformations

Module 2 (Text 2) **14 Hours**

Chapter 2

1. 2.3: Division of polynomials, quotient and remainder, method of detached coefficients
2. 2.4: The remainder theorem
3. 2.5: Synthetic Division
4. 2.7: Taylor formula, expansion of a polynomial in powers of x − c

Chapter 3

1. 3.1: Algebraic equations, roots, maximum number of roots
2. 3.2: Identity theorem
3. 3.3: The Fundamental theorem of Algebra (statement only), factorization to linear factors, multiplicity of roots
4. 3.4: Imaginary roots of equations with real coefficients
5. 3. 5: Relations between roots and coefficients

Chapter 4

1. 4.1: Limits of roots
2. 4.2: Method to find upper limit of positive roots
3. 4.3: Limit for moduli of roots [only the method to find out upper limit from the auxiliary equation is required; derivation omitted]
4. 4.4: Integral roots
5. 4.5: Rational roots

Module 3 (Text 2) **14 Hours**

Chapter 5

1. 5.1: What is the solution of an equation, algebraic solution or solution by radical
2. 5.2: Carden's formula
3. 5.3: Discussion of solution
4. 5.4: Irreducible case

5. 5.6: Solutions of biquadratic equations, Ferrari method [example2 omitted]

Chapter 6

1. 6.1: Object of the Chapter
2. 6.2: The sign of a polynomial for small and large values of variables- locating roots of polynomial between two numbers having values of opposite sign- geometric illustration only-[rigorous reasoning in the starred section omitted]
3. 6.4: Corollaries- roots of odd and even degree polynomial, number of roots in an interval counted according to their multiplicity
4. 6.5: Examples
5. 6.6: An important identity and lemma [derivation not needed]
6. 6.7: Rolle's theorem [proof omitted], use in separating roots
7. 6.10: Descarte's rule of signs-only statement and illustrations are required

References:

1. George A Jennings: Modern Geometry with Applications *Universitext, Springer (1994) ISBN:0-387-94222-X*
2. Walter Meyer: Geometry (2006) ISBN:0-12-369427-0 and its Application(2/e) Elsevier, Academic Press
3. Judith N Cederberg: A Course in Modern Geometries(2/e) UTM,Springer (2001) ISBN: 978-1-4419-3193-1
4. Patric J Ryan: Euclidean and Non Euclidean Geometry-An Analytic Approach Cambridge University Press, International Student Edition (2009) ISBN:978-0-521- 12707-3
5. David C Kay: College Geometry: A Uni^ied Approach CRC Press Tayloe and Francic Group (2011) ISBN: 978-1-4398-1912-8 (Ebook-PDF)
6. James R Smart: Modern Geometries(5/e) Brooks/Cole Publishing Co., (1998) ISBN:0- 534-35188-3
7. Michele Audin: Geometry Universitext, Springer (2003) ISBN:3-540-43498-4
8. Dickson L.E: Elementary Theory of Equations John Wiley and Sons,Inc. NY(1914)
9. Turnbull H.W: Theory of Equations(4/e) Oliver and Boyd Ltd Edinburg (1947)

10. Todhunter I: An Elementary Treatise on the Theory of Equations(3/e) Macmillan and Co. London(1875) 1 William Snow Burnside and Arthur William Panton: The Theory of Equations with an Introduction to Binary Algebraic Forms Dublin University Press Series (1881)

Text:

1. Geometry(2/e): David A Brannan, Mathew F Espen, Jeremy J Gray *Cambridge University Press (2012) ISBN:978-1-107-64783-1*
2. Theory of Equations : J V Uspensky McGraw Hill Book Company, Inc. (1948) ISBN:07-066735-7

SEMESTER 6

MTS6 B10 REAL ANALYSIS

Number of Credits: 5

Contact Hours per week: 5

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 (Text 1) **18 Hours**

1. 5.1: Continuous Functions- *definition, sequential criteria for continuity, discontinuity criteria, examples of continuous and discontinuous functions, Dirichlet and Thomae function*
2. 5.3: Continuous Functions on Intervals- Boundedness Theorem, The Maximum-Minimum Theorem, Location of Roots Theorem, Bolzano's Intermediate Value Theorem, Preservation of Intervals Theorem
3. 5.4: Uniform Continuity- *definition, illustration*, Nonuniform Continuity Criteria, Uniform Continuity Theorem, Lipschitz Functions, *Uniform Continuity of Lipschitz Functions, converse,* The Continuous Extension Theorem, Approximation *by step functions & piecewise linear functions*, Weierstrass Approximation Theorem *(only statement)*

Module 2 (Text 2) **22 Hours**

1. 7.1: Riemann Integral –Partitions and Tagged Partitions, *Riemann sum, Riemann integrability, examples,* Some Properties of the Integral, Boundedness Theorem
2. 7.2: Riemann Integrable Functions-*Cauchy Criterion, illustrations*, The Squeeze Theorem, Classes

of Riemann Integrable Functions, *integrability of continuous and monotone functions*, The Additivity Theorem

3. 7. 3: The Fundamental Theorem-The Fundamental Theorem (First Form), The Fundamental Theorem (Second Form), Substitution Theorem, Lebesgue's integrability Criterion, *Composition Theorem, The Product Theorem*, Integration by Parts, *Taylor's Theorem with the Remainder*

Module 3(Text 1) **17 Hours**

1. 8.1. Pointwise and Uniform Convergence -*definition, illustrations,* The Uniform Norm, *Cauchy Criterion for Uniform Convergence*
2. 8.2 Interchange of Limits- *examples leading to the idea*, Interchange of Limit and Continuity, Interchange of Limit and Derivative *[only statement of theorem 8.2.3 required; proof omitted]* Interchange of Limit and Integral, Bounded convergence theorem (statement only) *[8.2.6 Dini's theorem omitted]*
3. 9.4 Series of Functions – *(A quick review of series of real numbers of section 3.7 without proof) definition, sequence of partial sum, convergence, absolute and uniform convergence*, Tests for Uniform Convergence, Weierstrass M-Test *(only upto and including 9.4.6)*

Module 4 (Text 2) **23 Hours**

Improper Riemann Integrals

1. 1.1: Definitions and examples
2. 1.2: Cauchy Principal Value
3. 1.3: Some Criteria of Existence
4. 2.1 Calculus Techniques ['2.1.1 Applications' Omitted]
5. 2.2 Integrals Dependent on Parameters- upto and including example 2.2.4 2.6:
6. 2.6 The Real Gamma and Beta Functions- *upto and including Example 2.6.18*

References:

1. Charles G. Denlinger: Elements of Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2011) ISBN:0-7637-7947-4 [Indian edition: ISBN- 9380853157]*
2. David Alexander Brannan: A First Course in Mathematical Analysis *Cambridge University Press, US (2006) ISBN: 9780521684248*
3. John M. Howie: Real Analysis *Springer Science & Business Media (2012) [Springer Undergraduate Mathematics Series] ISBN: 1447103416*
4. James S. Howland: Basic Real Analysis *Jones and Bartlett Publishers Sudbury, Massachusetts (2010) ISBN:0-7637-7318-2*

5. Terrace Tao: Analysis I & II (3/e) *TRIM 37 Springer Science+Business Media Singapore 2016; Hindustan book agency (2015) ISBN 978-981-10-1789-6 (eBook) & ISBN 978-981-10-1804-6 (eBook)*
6. Richard R Goldberg: Methods of Real Analysis *Oxford and IBH Publishing Co.Pvt.Ltd. New Delhi (1970)*
7. Saminathan Ponnusamy: Foundations of Mathematical Analysis Birkhauser (2012) ISBN 978-0-8176-8291-0
8. William F Trench: Introduction to Real Analysis *ISBN 0-13-045786-8*
9. Ajith Kumar & S Kumaresan: A Basic Course in Real Analysis *CRC Press, Taylor & Francis Group (2014) ISBN: 978-1-4822-1638-7 (eBook - PDF)*
10. Hugo D Junghenn: A Course in Real Analysis *CRC Press, Taylor & Francis Group (2015) ISBN: 978-1-4822-1928-9 (eBook - PDF)*

Text:

1. Introduction to Real Analysis(4/e): Robert G Bartle, Donald R Sherbert *John Wiley & Sons (2011) ISBN 978-0-471-43331-6*
2. Improper Riemann Integrals*:* Ioannis M. Roussos *CRC Press by Taylor & Francis Group, LLC (2014) ISBN: 978-1-4665-8808-0 (eBook - PDF)*

MTS6 B11 COMPLEX ANALYSIS

Number of Credits: 5

Contact Hours per week: 5

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 **21 Hours**

Analytic Functions

1. 3.1: Limit and Continuity- Limit of a complex function, condition for non existence of limit, real and imaginary parts of limit, properties of complex limits, continuity, discontinuity of principal square root function, properties of continuous functions, continuity of polynomial and rational functions, Bounded Functions, Branches, Branch Cuts and Points
2. 3.2 Differentiability and Analyticity – *Derivative of a complex Function, rules of differentiation, function that is nowhere differentiable,* Analytic functions, entire functions, singular points,

Analyticity of sum product and quotient, L'Hospital rule

3. 3.3 Cauchy Riemann Equations- Necessary condition for analyticity, *Criterion for non-analyticity*, sufficient condition for analyticity, *sufficient condition for differentiability, Cauchy Riemann equations in polar coordinates*
4. 3.4 Harmonic Functions- *definition, analyticity and harmonic nature,* harmonic conjugate functions, *finding harmonic conjugate*

Elementary Functions

1. 4.1 Exponential and logarithmic functions-Complex Exponential Function*, its derivative*, *analyticity*, *modulus argument and conjugate*, *algebraic properties*, *periodicity*, exponential mapping *and its properties,* Complex Logarithmic Function, *logarithmic identities*, principal value of a complex logarithm, *Ln* z as inverse function, derivative, logarithmic mapping*, properties, other branches*
2. 4.3 Trigonometric and Hyperbolic functions- Complex Trigonometric Functions, identities, *periodicity of sine and cosine*, Trigonometric equations *and their solution,* Modulus, zeroes analyticity, *[subsection 'Trigonometric Mapping' omitted]*, Complex Hyperbolic Functions, relation to *sine* and *cosine*

Module 2 **20 Hours**

Integration in the Complex plane

1. 5.1 Real Integrals- Definite Integral, *simple, smooth, closed curves,* Line integrals in the plane, Method of Evaluation-*curves defined parametrically and curves given as functions*, Orientation of a Curve
2. 5.2 Complex Integral-contours, *definition of* complex integral, complex valued function of a real variable, evaluation of contour integral, properties *of contour integral, ML-inequality*
3. 5.3 Cauchy-Goursat Theorem- simply and multiply connected regions, Cauchy theorem, Cauchy-Goursat theorem *for simply connected domain (without proof),* Multiply Connected Domains, *principle of deformation of contours*, *Cauchy-Goursat theorem for multiply connected domains, illustrations*
4. 5.4 Independence of Path- *definition, analyticity and path independence, anti-derivative*, *Fundamental theorem for contour integrals*, Some Conclusions, *Existence of anti-derivative*
5. 5.5 Cauchy's Integral Formulas & their Consequences- Cauchy's Two Integral Formulas, *illustration of their use*, Some Consequences of the Integral Formulas-cauchy's inequality, Liouville theorem, Morera's theorem, Maximum modulus theorem

Module 3 **15 Hours**

Series

1. 6.1 Sequences and Series- *definition, criteria for convergence*, Geometric series, *necessary condition for convergence*, test for divergence*, absolute and conditional convergence, Ratio test, root test,* Power Series*, circle of convergence, radius of convergence*, Arithmetic of Power Series
2. 6.2: Taylor Series- differentiation and integration of power series, *term by term differentiation and integration*, Taylor Seties, *Maclaurian series*, illustrations
3. 6.3: Laurent's Series- isolated singularities, *Laurent's Theorem [proof omitted], illustrations*

Module 4

Residues

1. 6.4: Zeros and Poles- classifications of isolated singular points, removable singularity, pole, essential singularity, order of zeros and poles
2. 6.5 Residues and Residue Theorem- residue, method of evaluation of residue at poles, (Cauchy's) Residue Theorem, illustrations
3. 6. 6 Some Consequences of Residue theorem-
4. 6.6.1: Evaluation of Real Trigonometric Integrals

References:

1. James Ward Brown, Ruel Vance Churchill: Complex variables and applications(8/e) *McGraw-Hill Higher Education, (2009) ISBN: 0073051942*
2. Alan Jeffrey: Complex Analysis and Applications(2/e) *Chapman and Hall/ CRC Taylor Francis Group (2006) ISBN:978-1-58488-553-5*
3. Saminathan Ponnusamy, Herb Silverman: Complex Variables with Applications *Birkhauser Boston (2006) ISBN:0-8176-4457-4*
4. John H. Mathews & Russell W. Howell: Complex Analysis for Mathematics and Engineering (6 /e)
5. H.A Priestly: Introduction to Complex Analysis(2/e) *Oxford University Press (2003) ISBN: 0 19 852562 1*
6. Jerrold E Marsden, Michael J Hoffman: Basic Complex Analysis (3/ e) W.H Freeman, N.Y. (1999) ISBN:0-7167- 2877- X

Text:

1. Complex Analysis A First Course with Applications (3/e): Dennis Zill & Patric Shanahan Jones and Barlett Learning (2015) ISBN:1-4496-9461-6

MTS6 B12 CALCULUS OF MULTI VARIABLE

Number of Credits: 4

Contact Hours per week: 5

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 **18 Hours**

1. 13.1 Functions of two or more variables- Functions of Two Variables, Graphs of Functions of Two Variables, Level Curves, Functions of Three Variables and Level Surfaces

2. 13.2 Limits and continuity-An Intuitive Definition of a Limit, *existence and non-existence of limit,* Continuity of a Function of Two Variables, Continuity on a Set, *continuity of polynomial and rational functions*, *continuity of composite functions,* Functions of Three or More Variables, The $\varepsilon - \delta$ Definition of a Limit

3. 13.3 Partial Derivatives- Partial Derivatives of Functions of Two Variables, *geometric interpretation*, Computing Partial Derivatives, Implicit Differentiation, Partial Derivatives of Functions of More Than Two Variables, Higher-Order Derivatives, *clairaut theorem, harmonic functions*

4. 13.4 Differentials- Increments, The Total Differential*, interpretation,* Error in Approximating Δz by dz *[only statement of theorem1 required; proof omitted]* Differentiability of a Function of Two Variables, *criteria*, Differentiability and Continuity, Functions of Three or More Variables

5. 13.5 The Chain rule- The Chain Rule for Functions Involving One Independent Variable, The Chain Rule for Functions Involving Two Independent Variables, The General Chain Rule, Implicit Differentiation

Module 2 **16 Hours**

1. 13.6 Directional Derivatives and Gradient vectors - The Directional Derivative, The Gradient of a Function of Two Variables, Properties of the Gradient, Functions of Three Variables

2. 13.7 Tangent Planes and Normal Lines- Geometric Interpretation of the Gradient, Tangent Planes and Normal Lines, Using the Tangent Plane of f to approximate the Surface $z = f(x, y)$

3. 13.8 Extrema of Functions of two variables - Relative and Absolute Extrema, Critical Points—Candidates for Relative Extrema, The Second Derivative Test for Relative Extrema, Finding the Absolute Extremum Values of a Continuous Function on a Closed Set

4. 13.9 Lagrange Multipliers- Constrained Maxima and Minima, The Method of Lagrange Multipliers*, Lagrange theorem,* Optimizing a Function Subject to Two Constraints

Module 3 **21 Hours**

1. 4.1 Double integrals- An Introductory Example, Volume of a Solid Between a Surface and a Rectangle, The Double Integral Over a Rectangular Region, Double Integrals Over General Regions, Properties of Double Integrals
2. 14.2 Iterated Integrals-Iterated Integrals Over Rectangular Regions, Fubini's Theorem for Rectangular Regions, Iterated Integrals Over Non-Rectangular Regions*, y- simple and x- simple regions, advantage of changing the order of integration*
3. 14.3 Double integrals in polar coordinates- Polar Rectangles, Double Integrals Over Polar Rectangles, Double Integrals Over General Regions, r- simple region, method of evaluation
4. 14.4 Applications of Double integral- Mass of a Lamina, Moments and Center of Mass of a Lamina, Moments of Inertia, Radius of Gyration of a Lamina
5. 14.5 Surface Area- Area of a Surface $z = f(x, y)$, Area of Surfaces with Equations $y = g(x, z)$ and $x= h(y, z)$
6. 14.6 Triple integrals- Triple Integrals Over a Rectangular Box, *definition, method of evaluation as iterated integrals,* Triple Integrals Over General Bounded Regions in Space, Evaluating Triple Integrals Over General Regions, *evaluation technique,* Volume, Mass, Center of Mass, and Moments of Inertia
7. 14.7 Triple Integrals in cylindrical and spherical coordinates- *evaluation of integrals in* Cylindrical Coordinates, Spherical Coordinates
8. 14.8 Change of variables in multiple integrals- Transformations, Change of Variables in Double Integrals *[only the method is required; derivation omitted], illustrations*, Change of Variables in Triple Integrals

Module 4 **25 Hours**

1. 15.1 Vector Fields- *V.F. in two and three dimensional space,* Conservative Vector Fields
2. 15.2 Divergence and Curl- *Divergence- idea and definition*, Curl- *idea and definition*
3. 15.3 Line Integrals- *Line integral w.r.t. arc length-motivation, basic idea and definition*, Line Integrals with Respect to Coordinate Variables, *orientation of curve* Line Integrals in Space, Line Integrals of Vector Fields
4. 15.4 Independence of Path and Conservative Vector Fields-*path independence through example, definition, fundamental theorem for line integral,* Line Integrals Along Closed Paths, *work done by conservative vector field,* Independence of Path and Conservative Vector Fields, Determining Whether a Vector Field Is Conservative, *test for conservative vector field* Finding a Potential Function, Conservation of Energy
5. 15.5 Green's Theorem- Green's Theorem for Simple Regions, *proof of theorem for simple regions, finding*

area using line integral, Green's Theorem for More General Regions, Vector Form of Green's Theorem

6. 15.6 Parametric Surfaces-Why We Use Parametric Surfaces, Finding Parametric Representations of Surfaces, Tangent Planes to Parametric Surfaces, Area of a Parametric Surface *[derivation of formulaomitted]*

7. 15.7 Surface Integrals-Surface Integrals of Scalar Fields, *evaluation of surface integral for surfaces that are graphs , [derivation of formula omitted; only method required]* Parametric Surfaces, *evaluation of surface integral for parametric surface*, Oriented Surfaces, Surface Integrals of Vector Fields- *de*ﬁ*inition,* ﬁ*lux integral*, *evaluation of surface integral for graph[method only],* Parametric Surfaces, *evaluation of surface integral of a vector* ﬁ*ield for parametric surface [method only]*

8. 15.8 The Divergence Theorem-*divergence theorem for simple solid regions* (*statement only*), *illustrations*, Interpretation of Divergence

9. 15.9 Stokes Theorem-*generalization of Green's theorem –Stokes Theorem*, *illustrations*, Interpretation of Curl

References:

1. Joel Hass, Christopher Heil & Maurice D. Weir: Thomas' Calculus(14/e) *Pearson (2018) ISBN 0134438981*
2. Robert A Adams & Christopher Essex: Calculus: *A complete Course (8/e) Pearson Education Canada (2013) ISBN:* 032187742X
3. Jon Rogawski: Multivariable Calculus *Early Transcendentals* (2/e) W. H. Freeman and Company (2012) *ISBN: 1-4292-3187-4*
4. Anton, Bivens & Davis: Calculus *Early Transcendentals* (10/e) John Wiley & Sons, Inc. (2012) ISBN: 978-0-470-64769-1
5. James Stewart: Calculus (8/e) *Brooks/Cole Cengage Learning (2016) ISBN: 978-1-285-74062-1*
6. Jerrold E. Marsden & Anthony Tromba: Vector Calculus (6/e) *W. H. Freeman and Company, New York (2012) ISBN: 978-1-4292-1508-4*
7. Arnold Ostebee & Paul Zorn: Multivariable Calculus (2/e) *W. H. Freeman Custom Publishing, N.Y. (2008) ISBN: 978-1-4292-3033-9*

Text:

1. Calculus: Soo T Tan *Brooks/Cole, Cengage Learning (2010) ISBN 0- 534-46579-X)*

MTS6 B13 DIFFERENTIAL EQUATIONS

Number of Credits: 4

Contact Hours per week: 5

Course Evaluation: Internal – 20 Marks + External – 80 Marks

Course Outline

Module 1 **22 Hours**

2. 1.1: Some Basic Mathematical Models; Direction Fields
3. 1.2: Solutions of some Differential equations
4. 1.3: Classification of Differential Equations
5. 2.1: Linear Differential Equations; Method of Integrating Factors
6. 2.2: Separable Differential Equations
7. 2.3: Modelling with First Order Differential Equations
8. 2.4: Differences Between Linear and Nonlinear Differential Equations
9. 2.6: Exact Differential Equations and Integrating Factors
10. 2.8: The Existence and Uniqueness Theorem *(proof omitted)*

Module 2 **23 Hours**

1. 3.1: Homogeneous Differential Equations with Constant Coefficients
2. 3.2: Solutions of Linear Homogeneous Equations; the Wronskian
3. 3.3: Complex Roots of the Characteristic Equation
4. 3.4: Repeated Roots; Reduction of Order
5. 3.5: Non-homogeneous Equations; Method of Undetermined Coefficients
6. 3.6: Variation of Parameters
7. 5.2: Series solution near an ordinary point, part 1
8. 5.3: Series solution near an ordinary point, part 2

Module 3 **15 Hours**

1. 6.1: Definition of the Laplace Transform
2. 6.2: Solution of Initial Value Problems
3. 6.3: Step Functions
4. 6.5: Impulse Functions
5. 6.6: The Convolution Integral

Module 4 **20 Hours**

1. 10.1: Two-Point Boundary Value Problems
2. 10.2: Fourier Series
3. 10.3: The Fourier Convergence Theorem
4. 10.4: Even and Odd Functions
5. 10.5: Separation of Variables; Heat Conduction in a Rod
6. 10.7: The Wave Equation: Vibrations of an Elastic String

References:

1. Dennis G Zill &Michael R Cullen: Differential Equations with Boundary Value Problems(7/e): *Brooks/Cole Cengage Learning (2009) ISBN: 0-495-10836-7*
2. R Kent Nagle, Edward B. Saff & Arthur David Snider: Fundamentals of Differential Equations(8/e) *Addison-Wesley (2012) ISBN: 0-321-74773-9*
3. C. Henry Edwards & David E. Penney: Elementary Differential Equations (6/e) *Pearson Education, Inc. New Jersey (2008) ISBN 0-13-239730-7*
4. John Polking, Albert Boggess & David Arnold: Differential Equations with Boundary Value Problems(2/e) *Pearson Education, Inc New Jersey (2006) ISBN 0-13-186236-7*
5. Henry J. Ricardo: A Modern Introduction to Differential Equations(2/e*) Elsevier Academic Press (2009) ISBN: 978-0-12-374746-4*
6. James C Robinson: An Introduction to Ordinary Differential Equations *Cambridge University Press (2004) ISBN: 0-521-53391-0*

Text:

1. Elementary Differential Equations and Boundary Value Problems (11/e): William E Boyce, Richard C Diprima And Douglas B Meade *John Wiley & Sons (2017) ISBN: 1119169879*

Elective

MTS6 B14 (E01) GRAPH THEORY

Number of Credits: 2

Contact Hours per week: 3

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **16 Hours**

1. 1.1 Definition of a graph
2. 1.2 Graphs as models
3. 1.3 More definitions
4. 1.4 Vertex degrees
5. 1.5 Sub graphs
6. 1.6 Paths and Cycles
7. 1.7 Matrix representation of a graph *[up to Theorem 1.6; proof of Theorem 1.5 is omitted]*

Module 2 **16 Hours**

1. 2.1 Definitions and Simple Properties
2. 2.2 Bridges *[Proof of Theorem 2.6 and Theorem 2.9 are omitted]*
3. 2.3 Spanning Trees
4. 2.6 Cut Vertices and Connectivity *[Proof of Theorem 2.21omitted]*

Module 3 **16 Hours**

1. 3.1 Euler Tour [up to Theorem 3.2, proof of Theorem 3.2 omitted]
2. 3.3 Hamiltonian Graphs *[Proof of Theorem 3.6 omitted]*
3. 5.1 Plane and Planar graphs *[Proof of Theorem 5.1 omitted]*
4. 5.2 Euler's Formula *[Proofs of Theorems 5.3 and Theorem 5.6omitted]*

References:

1. R.J. Wilson: Introduction to Graph Theory, 4th ed., *LPE, Pearson Education*
2. J.A. Bondy& U.S.R. Murty: Graph Theory with Applications
3. J. Clark & D.A. Holton: A First Look at Graph Theory, *Allied Publishers*
4. N. Deo: Graph Theory with Application to Engineering and Computer Science, *PHI.*

Text:

1. A First Look at Graph Theory: John Clark & Derek Allan Holton, *Allied Publishers, First Indian Reprint 1995*

Elective

MTS6 B14 (E02) TOPOLOGY OF METRIC SPACES

Number of Credits: 2

Contact Hours per week: 3

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **19 Hours**

Chapter 1: *Metrics*

1. 1.1 Metric Spaces
2. 1.3 Metric Subspaces and Metric Superspaces
3. 1.4 Isometrics
4. 1.6 Metrics on Products
5. 1.7 Metrics and Norms on Linear Spaces *[example1.7.8 omitted]*

Chapter 2: *Distance*

1. 2.1 Diameter
2. 2.2 Distances from points to sets
3. 2.3 Inequalities for Distances
4. 2.4 Distances to Unions and Intersections
5. 2.5 Isolated Points
6. 2.6 Accumulation Points
7. 2.7 Distances from Sets to Sets

Chapter 3: *Boundary*

1. 3.1 Boundary Points
2. 3.2 Sets with Empty Boundary
3. 3.3: Boundary Inclusion

4. 3.6 Closure and Interior
5. 3.7 Inclusion of Closures and Interiors

Module 2 **17 Hours**

Chapter 4 ***Open, Closed and Dense Subsets***

1. 4.1: Open and Closed Subsets
2. 4.2: Dense Subsets
3. 4.3 Topologies
4. 4.4 Topologies on Subspaces and Superspaces
5. 4.5: Topologies on Product Spaces

Chapter 5 ***Balls***

1. 5.1: Open and Closed Balls
2. 5.2: Using Balls

Chapter 6 ***Convergence***

1. 6.1: Definition of Convergence for Sequences
2. 6.2: Limits
3. 6.4: Convergence in Subspaces and Superspaces
4. 6.6: Convergence Criteria for Interior and Closure
5. 6.7: Convergence of Subsequences
6. 6.8: Cauchy Sequences

Module 3 **12 Hours**

Chapter 7 ***Bounds***

1. 7.1: Bounded Sets
2. 7.4: Spaces of Bounded Functions
3. 7.6: Convergence and Boundedness
4. 7.7: Uniform and Pointwise Convergence

Chapter 8 ***Continuity***

1. 8.1: Local Continuity
2. 8.3: Global Continuity

3. 8.5: Continuity of Compositions

Chapter 11 ***Connectedness***

1. 11.1: Connected Metric Spaces
2. 11.2: Connected Subsets
3. 11.3: Connectedness and Continuity

References:

1. E.T.Copson: Metric Spaces *Cambridge University Press(1968)ISBN:0 521 35732 2*
2. Irving Kaplansky: Set Theory and Metric Spaces *Allyn and Bacon,Inc. Boston(1972)*
3. S. Kumaresan: Topology of Metric Spaces *Alpha Science International Ltd. (2005) ISBN: 1-84265-250-8*
4. Wilson A Sutherland: Introduction to Metric and Topological Spaces(2/e) *Oxford University Press (2009) ISBN:978-0-19-956308-1*
5. Mohamed A. Khamsi and William A. Kirk: An Introduction to Metric Spaces and Fixed Point Theory *John Wiley & Sons, Inc (2001) ISBN 0-471- 41825-0*

Text:

1. Metric Spaces: *Mícheál Ó Searcóid Undergraduate Mathematics Series Springer-Verlag London Limited (2007) ISBN: 1-84628-369-8*

Elective

MTS6 B14 (E03) MATHEMATICAL PROGRAMMING WITH PYTHON AND LATEX

Number of Credits: 2

Contact Hours per week: 3

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **15 Hours**

Basics of Python Programming

Chapter 2 Programming in Python: Two modes of using Python, Interpreter Variables and Data Types, Operators and their Precedence, Python Strings, Slicing, Python Lists, Mutable and Immutable Types, Input from the Keyboard, Iteration: while and for loops, Python Syntax, Colon& Indentation, Syntax of 'for loops', Conditional Execution: if, else if and else, Modify loops : break and continue, Line joining, Functions, Scope of variables, Optional and Named Arguments, More on Strings and Lists, split and join, Manipulating Lists, Copying Lists, Python Modules and Packages, Different ways to import, Packages, File Input/Output, The pickle module, Formatted Printing, Exception Handling, Turtle Graphics.

Chapter 3 Arrays and Matrices: The NumPy Module, Vectorized Functions. (sec. 2.1 to 2.19, 3.1 to 3.2)

Module 2 **20 Hours**

Applications of Python Programming

Chapter 4 Data visualization: The Matplotlib Module, Plotting mathematical functions, Famous Curves, Power Series, Fourier Series, 2D plot using colors, Meshgrids, 3D Plots, Mayavi, 3D visualization

Chapter 6 Numerical methods: Numerical Differentiation, Numerical Integration, Ordinary Differential Equations, Polynomials, Finding roots of an equation, System of Linear Equations, Least Squares Fitting, Interpolation.

(sec. 4.1 to 4.6, 4.8 to 4.10, 6.1 to 6.8)

Module 3 **13 Hours**

Latex

Chapter 5 Type setting using LATEX: Document classes, Modifying Text, Dividing the document, Environments, Typesetting Equations, Arrays and matrices, Floating bodies, Inserting Images, Example, Application

(sec. 5.1 to 5.8)

Practical

A practical examination, based on following topics, should be conducted for the *internal assessment only*.

Part A: Plotting

1. Cartesian plot of polynomials showing all zeros
2. Cartesian plot of quotient of polynomials
3. Cartesian plot of functions showing asymptotes
4. Parametric plot of curves
5. Polar plot of curves
6. Plot Pi chart
7. Plot 3D curves
8. Plot 3D surfaces

Part B: Numerical Analysis

1. Bisection Method
2. Newton-Raphson Method
3. Numerical differentiation
4. Trapezoidal rule
5. Simpson's rule
6. Euler Method to solve ODE
7. Fourth order RK Method to solve ODE

Part C: Latex

1. General documentation
2. Tables
3. Writing equations

Mark distribution for practical examination *as test paper* (Total 6 Marks) Part A: 2 marks, Part B: 2 marks, Part C: 2 marks, Practical Record *as Assignment*: 3 marks

References:

1. Saha, Amit: Doing Math with Python: Use Programming to Explore Algebra, Statistics, Calculus, and More*!. No Starch Press, 2015*.
2. Nunez-Iglesias, Juan, Stefan van der Walt, and Harriet Dashnow: "Elegant SciPy: The Art of Scienti^ic Python." (2017).
3. Stewart, John M.: Python for scientists. *Cambridge University Press, 2017.*
4. Kinder, Jesse M., and Philip Nelson: A student's guide to Python for physical modeling. *Princeton University Press, 2018*.
5. McGreggor, Duncan: Mastering matplotlib. *Packt Publishing Ltd, 2015*
6. Lamport, Leslie. LaTeX: A Document Preparation System(2/e) *Pearson Education India, 1994.*
7. Hahn, Jane: LATEX for Everyone. *Prentice Hall PTR, 1993*
8. Grätzer, George: Math into LATEX. *Springer Science & Business Media, 2013*

Text:

1. Python for Education - Learning Maths and Physics using Python: Ajith Kumar B.P *Inter University Accelerator Centre 2010*

OPEN COURSE

(For Students not having Mathematics as Core Course)

MTS5 D01 APPLIED CALCULUS

Number of Credits: 3

Contact Hours per week: 3

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **16 Hours**

Chapter 1: Functions, Graphs, and Limits

1. 1.1: Functions
2. 1.2: The Graph of a Function
3. 1.3: Linear Functions
4. 1.4: Functional Models
5. 1.5: Limits
6. 1.6: One sided limits and continuity

Chapter 2: Differentiation: Basic Concepts

1. 2.1: The Derivative
2. 2.2: Techniques of Differentiation
3. 2.3: Product and quotient rules: Higher order derivatives *[proof of product and quotient rules omitted]*
4. 2.4: The Chain rule *[proof of general power rule omitted]*

Module 2 **18 Hours**

1. 2.5: Marginal Analysis and Applications using increments
2. 2.6: Implicit Differentiation and Related Rates

Chapter 3: Additional Applications of Derivative

1. 3.1: Increasing and Decreasing Functions; Relative Extrema,
2. 3.2: Concavity and Points of Inflection
3. 3.4: Optimization; Elasticity of Demand

4. 3.5: Additional Applied Optimization

Chapter 4: Exponential and Logarithmic Functions

1. 4.1: Exponential functions; continuous compounding
2. 4.2: Logarithmic functions

Module 3 **14 Hours**

Chapter 5: Integration

1. 5.1: Anti-differentiation: The Indefinite Integral
2. 5.2: Integration by Substitution
3. 5.3: The Definite Integral and the Fundamental Theorem of Calculus *[only statement of FTC required; Justification given at the end of the section omitted]*
4. 5.5: Additional Applications to Business and Economics
5. 5.6: Additional Applications to the Life and Social Sciences *[The derivation of volume formula omitted; only the formula and its applications required]*

References:

1. Soo T Tan: Applied Calculus for the Managerial, Life, and social sciences(8/e) *Cengage Learning (2011) ISBN: 978-0-495-55969-6*
2. Ron Larson : Brief Calculus *An Applied Approach(8/e) Houghton Mifflin Company(2009)ISBN: 978-0-618-95847-4*
3. Stefan Waner, Steven R. Costenoble: Finite Mathematics and Applied Calculus(5/e) *Brooks/Cole Cengage Learning (2011) ISBN: 978-1-4390-4925-9*
4. Frank C. Wilson, Scott Adamson: Applied Calculus *Houghton Mifflin Harcourt Publishing Company (2009)*
5. Geoffrey C. Berresford, Andrew M. Rockett: Applied Calculus(7/e) *Cengage Learning 2016) ISBN: 978-1-305-08531-2*

Text:

1. Calculus: For Business, Economics, and the Social and Life Sciences BRIEF (10/e): Laurence D.Hoffmann, Gerald L.Bradley McGrow-Hill (2010) ISBN:978-0-07-353231-8

Open Course

(For Students not having Mathematics as Core Course)

MTS5 D02 DISCRETE MATHEMATICS FOR BASIC AND APPLIED SCIENCES

Number of Credits: 3

Contact Hours per week: 3

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **14 Hours**

Chapter-1 Logic

1. 1.1: Propositions and Truth Values
2. 1.2: Logical Connectives and Truth Tables- Disjunction, Conditional Propositions, Bi conditional Propositions
3. 1.3: Tautologies and Contradictions
4. 1.4: Logical Equivalence and Logical Implication- More about conditionals
5. 1.5: The Algebra of Propositions- The Duality Principle, Substitution Rule
6. 1.6: Argument
7. 1.7: Formal Proof of the Validity of Arguments
8. 1.8: Predicate Logic- *The Universal Quantifier, The Existential Quantifier, Two-Place Predicates, Negation of Quantified Propositional Functions*
9. 1.9: Arguments in Predicate Logic - *Universal Specification* (*US*), *Universal Generalization* (*UG*), *Existential Specification* (*ES*), *Existential Generalization* (*EG*)

Module 2 **16 Hours**

Chapter-8 Algebraic Structures

1. 8.1: Binary Operations and Their Properties
2. 8.2: Algebraic Structures- *Semigroups*
3. 8.3.: More about Groups
4. 8.4.: Some Families of Groups- *Cyclic Groups, Dihedral Groups, Groups of Permutations*
5. 8.5: Substructures
6. 8.6: Morphisms

Chapter -10 Boolean Algebra

1. 10.1.: Introduction
2. 10.2.: Properties of Boolean Algebras
3. 10.3: Boolean Functions
4. 10.4: Switching Circuits
5. 10.5: Logic Networks
6. 10.6: Minimization of Boolean Expressions

Module 3 **18 Hours**

Chapter-11 Graph Theory

1. 11.1: Definitions and Examples
2. 11.2: Paths and Cycles
3. 11.3: Isomorphism of Graphs
4. 11.4: Trees
5. 11.5.: Planar Graphs *[proof of Euler formula omitted]*
6. 11.6: Directed Graphs

Chapter-12 Application of Graph Theory

1. 12.2: Rooted Trees
2. 12.3: Sorting
3. 12.4: Searching Strategies

References:

1. Edward R. Scheinerman: Mathematics *A Discrete Introduction (3/e) Brooks/Cole, Cengage Learning (2013) ISBN: 978-0-8400-4942-1*
2. Gary Haggard, John Schlipf, Sue Whitesides: Discrete Mathematics for Computer Science *Thomson Brooks/Cole (2006) ISBN:0-534-49601-x*
3. DPAcharjya, Sreekumar: Fundamental Approach to Discrete Mathematics *New Age International Publishers (2005) ISBN: 978-81-224-2304-4*
4. Gary Chartrand Ping Zhang: Discrete Mathematics *Waveland Press, Inc (2011) ISBN: 978-1-57766-730-8*
5. Tom Jenkyns, Ben Stephenson: Fundamentals of Discrete Math for Computer Science *A Problem-Solving Primer Springer-Verlag London (2013) ISBN: 978-1-4471-4068-9*
6. Faron Moller, Georg Struth: Modelling Computing *Systems Mathematics for Computer Science*

Springer-Verlag London (2013) ISBN 978-1-84800-321-7

Text:

1. Discrete Mathematics; Proofs, Structures and Applications (3/e): *Rowan Garnier & John Taylor CRC Press, Taylor & Francis Group (2009) ISBN:978-1-4398-1280-8(hardback)/ 978-1-4398-1281-5 (eBook - PDF)*

Open Course

(For Students not having Mathematics as Core Course)

MTS5 D03 LINEAR MATHEMATICAL MODELS

Number of Credits: 3

Contact Hours per week: 3

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **18 Hours**

Chapter 1 Linear Functions

1. 1.1: Slopes and Equations of Lines
2. 1.2: Linear Functions and Applications
3. 1.3: The Least Squares Line

Chapter 2 Systems of Linear Equations and Matrices

1. 2.1: Solution of Linear Systems by the Echelon Method
2. 2.2: Solution of Linear Systems by the Gauss-Jordan Method
3. 2.3: Addition and Subtraction of Matrices
4. 2.4: Multiplication of Matrices
5. 2.5: Matrix Inverses
6. 2.6: Input-Output Models

Module 2 **12 Hour**

Chapter 3 Linear Programming: The Graphical Method

1. 3.1: Graphing Linear Inequalities
2. 3.2: Solving Linear Programming Problems Graphically
3. 3.3: Applications of Linear Programming

Module 3 **18 Hours**

Chapter 4 Linear Programming: The Simplex Method

1. 4.1: Slack Variables and the Pivot
2. 4.2: Maximization Problems
3. 4.3: Minimization Problems; Duality
4. 4.4: Nonstandard Problems

References:

1. Soo T Tan: Finite Mathematics For the Managerial, Life, and social sciences(11/e) *Cengage Learning (2015) ISBN: 1-285-46465-6*
2. Ronald J. Harshbarger, James J. Reynolds: Mathematical Applications for the Management, Life, and Social Sciences (9/e) *Brooks/Cole Cengage Learning (2009) ISBN: 978-0-547-14509-9*
3. Stefan Waner, Steven R. Costenoble: Finite Mathematics and Applied Calculus(5/e) *Brooks/Cole Cengage Learning (2011) ISBN: 978-1-4390-4925-9*
4. Seymour Lipschutz, John J. Schiller, R. Alu Srinivasan: Beginning Finite Mathematics *Schaum's Outline Series, McGraw-Hill (2005)*
5. Howard L. Rolf: Finite Mathematics *Enhanced Edition*(7/e) *Brooks/Cole, Cengage Learning (2011) ISBN:978-0-538-49732-9*
6. Michael Sullivan: Finite Mathematics An Applied Approach(11/e*) John Wiley & Sons, Inc (2011) ISBN: 978-0470-45827-3*

Text:

Finite Mathematics and Calculus with Applications (9/e) *Margaret L. Lial, Raymond N. Greenwell & Nathan P. Ritchey* Pearson Education, Inc (2012) ISBN: 0-321-74908-1

Open Course

(For Students not having Mathematics as Core Course)

MTS5 D04 MATHEMATICS FOR DECISION MAKING

Number of Credits: 3

Contact Hours per week: 3

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **14 Hour**

Chapter-1 Introduction to Statistics

1. 1.1: An Overview of Statistics
2. 1.2: Data Classification
3. 1.3: Data Collection and Experimental Design

Chapter - 2 Descriptive Statistics

1. 2.1: Frequency Distributions and their Graphs
2. 2.2: More Graphs and Displays
3. 2.3: Measures of Central Tendency
4. 2.4: Measures of Variation
5. 2.5: Measures of Position

Module 2 **12 Hours**

Chapter - 3 Probability

1. 3.1: Basic Concepts of Probability and Counting
2. 3.2: Conditional Probability and the Multiplication Rule
3. 3.3: The Addition Rule
4. 3.4: Additional topics in probability and counting

Module 3 **22 Hours**

Chapter - 4 Discrete Probability Distribution

1. 4.1: Probability Distributions
2. 4.2: Binomial Distributions
3. 4.3: More Discrete Probability Distributions

Chapter5 Normal Probability Distribution

1. 5.1: Introduction to Normal distributions and Standard Normal Distributions
2. 5.2: Normal Distributions: Finding Probabilities
3. 5.3: Normal Distributions: Finding Values

References:

1. Mario F. Triola: Elementary Statistics(13/e): *Pearson Education, Inc (2018) ISBN: 9780134462455*
2. Neil A. Weiss: Elementary Statistics(8/e) *Pearson Education, Inc (2012) ISBN: 978-0-321-69123-1*
3. Nancy Pfenning: Elementary Statistics: Looking at Big Picture *Brooks/ Cole Cengage Learning (2011) ISBN: 978-0-495-01652-6*
4. Frederick J Gravetter, Larry B. Wallnau: Statistics for the Behavioral Sciences (10/e) *Cengage Learning (2017) ISBN: 978-1-305-50491-2*
5. Seymour Lipschutz, John J. Schiller, R. Alu Srinivasan: Beginning Finite Mathematics *Schaum's Outline Series, McGraw-Hill (2005)*
6. Michael Sullivan: Finite Mathematics An Applied Approach(11/e*) John Wiley & Sons, Inc (2011) ISBN: 978-0470-45827-3*

Text:

1. Elementary Statistics: Picturing the World (6/e) *Ron Larson & Betsy Farber Pearson Education, Inc (2015) ISBN: 978-0-321-91121-6*

COMPLEMENTARY COURSE

Semester - 1

MT1 C01 MATHEMATICS - 1

Number of Credits: 3

Contact Hours per week: 4

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **14 Hours**

1. 1.1: Introduction to the derivative-instantaneous velocity, slope of tangent line, differentiating simplest functions
2. 1.2: Limits- Notion of limit, basic properties, derived properties, continuity, continuity of rational functions, *one sided limit, limit involving* $\pm\infty$
3. 1.3: The derivative as Limit- formal definition, *examples*, *differentiability and continuity*, Leibnitz notation,
4. 1.4: Differentiating Polynomials-power rule, sum rule etc.,
5. 1.5: Product and quotients- product, quotient, reciprocal & integral power rule
6. 1.6: Linear Approximation and Tangent Lines- equation of tangent line and linear approximation, *illustrations*

Module 2 **13 Hours**

1. 2.1: Rate of change and Second derivative- linear or proportional change, rates of change, second derivative,
2. 2.2: The Chain Rule- power of a function rule, chain rule,
3. 2.3: Fractional Power & Implicit Differentiation-rational power of a function rule, implicit differentiation
4. 2.4: Related rates and parametric curves- Related rates, parametric curves, *word problems involving related rates*
5. 2.5: Anti derivatives- anti differentiation and indefinite integrals, anti-differentiation rules

Module 3 **18 Hours**

1. 3.1: Continuity and Intermediate value theorem-IVT: first and second version
2. 3.2: Increasing and decreasing function- Increasing and decreasing test, critical point test, first derivative test
3. 3.3: Second derivative and concavity- second derivative test for local maxima, minima and concavity, inflection points
4. 3.4: Drawing of Graphs- graphing procedure*, asymptotic behavior*
5. 3.5: Maximum- Minimum Problems- maximum and minimum values on intervals, extreme value theorem, closed interval test, *word problems*
6. 3.6: The Mean Value Theorem- The MVT, consequences of MVT-*Rolls Theorem, horserace theorem*
7. 11.2: L'Hospital rule- Preliminary version, strengthened version

Module 4 **19 Hours**

1. 4.1: Summation- summation, *distance and velocity*, properties of summation, telescoping sum (quick introduction- relevant ideas only)
2. 4.2: Sums and Areas-step functions, area under graph *and its counterpart in distance-velocity problem*
3. 4.3: The definition of Integral- signed area *(The counterpart of signed area for our distance-velocity problem),* The integral, Riemann sums
4. 4.4: The Fundamental Theorem of Calculus-*Arriving at FTC intuitively using distance velocity problem,* Fundamental integration Method, *proof of FTC*, Area under graph, displacements and velocity
5. 4.5: Definite and Indefinite integral- indefinite integral test, properties of definite integral, fundamental theorem of calculus: alternative version *(interpretation and explanation in terms of areas)*
6. 4.6: Applications of the Integral- Area between graphs, area between intersecting graphs, total changes from rates ofchange,
7. 9.1: Volume by slice method- the slice method, volume of solid of revolution by Disk method
8. 9.3: Average Values and the Mean Value Theorem for Integrals- *motivation and definition of average*

value, illustration, geometric and physical interpretation, the Mean Value Theorem for Integrals

References:

1. Soo T Tan: Calculus *Brooks/Cole, Cengage Learning (2010) ISBN 0-534- 46579-X*
2. Gilbert Strang: Calculus *Wellesley Cambridge Press (1991) ISBN:0-9614088- 2-0*
3. Ron Larson. Bruce Edwards: Calculus(11/e) *Cengage Learning (2018) ISBN: 978-1-337-27534-7*
4. Robert A Adams & Christopher Essex: Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN:* 0321877403
5. Joel Hass, Christopher Heil & Maurice D. Weir: Thomas' Calculus(14/e) *Pearson (2018) ISBN 0134438981*
6. Jon Rogawski & Colin Adams: Calculus *Early Transcendentals* (3/e) *W. H. Freeman and Company (2015) ISBN: 1319116450*

Text:

1. Calculus I (2/e): Jerrold Marsden & Alan Weinstein *Springer-Verlag New York Inc (1985) ISBN 0-387-90974-5*
2. Calculus II (2/e): Jerrold Marsden & Alan Weinstein *Springer-Verlag New York Inc (1985) ISBN 0-387-90975-3*

Complementary Course

Semester - 2

MT2 C02 MATHEMATICS - 2

Number of Credits: 3

Contact Hours per week: 4

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 (Text 1 & 2) **18 Hours**

1. 5.1: Polar coordinates and Trigonometry – Cartesian and polar coordinates

   (*Only representation of points in polar coordinates, relationship between Cartesian and polar coordinates, converting from one system to another and regions represented by inequalities in polar system are required*)

2. 5.3: Inverse functions-inverse function test, inverse function rule

3. 5.6: Graphing in polar coordinates- *Checking symmetry of graphs given in polar equation, drawings,* tangents to graph in polar coordinates

4. 8.3: Hyperbolic functions- hyperbolic sine, cosine, tan etc., derivatives, anti-differentiation formulas

5. 8.4: Inverse hyperbolic functions- inverse hyperbolic functions *(their derivatives and anti-derivatives)*

6. 10.3: Arc length and surface area- Length of curves, Area of surface of revolution about x *and* y axes

Module 2 (Text 2) **20 Hours**

1. 11.3: Improper integrals- integrals over unbounded intervals, comparison test, integrals of unbounded functions

2. 11.4: Limit of sequences and Newton's method- $\varepsilon - N$ definition, limit of powers, comparison test, Newton's method

3. 11.5: Numerical Integration- Riemann Sum, Trapezoidal Rule, Simpson's Rule

4. 12.1: The sum of an infinite series- convergence of series, properties of limit of sequences (*statements only*), geometric series, algebraic rules for series, the i^{th} term test

5. 12.2: The comparison test and alternating series- comparison test, ratio comparison test, alternating series, alternating series test, absolute and conditional convergence

Module 3 (Text 3) **12 Hours**

1. 7.6: Vector spaces – *definition, examples, subspaces, basis, dimension, span*

2. 7.7: Gram-Schmidt Orthogonalization Process- *orthonormal bases for* $\mathbb{R}^n$, construction of orthonormal basis of $\mathbb{R}^n$

3. 8.2: Systems of Linear Algebraic Equations- General form, solving systems, augmented matrix, Elementary row operations, Elimination Methods- *Gaussian elimination, Gauss–Jordan elimination, row echelon form, reduced row echelon form*, *inconsistent system*, networks, homogeneous system, *over and underdetermined system*

4. 8.3: Rank of a Matrix- *definition*, row space, rank by row reduction, rank and linear system*, consistency of linear system*

5. 8.4: Determinants- *definition*, *cofactor* *(quick introduction)*

6. 8.5: Properties of determinant- properties, *evaluation of determinant by* row reducing to triangular form

Module 4 (Text 3) **14 Hours**

1. 8.6: Inverse of a Matrix – finding inverse, properties *of inverse*, adjoint method, row operations method, using inverse to solve a linear system

2. 8.8: The eigenvalue problem- De^inition*, #inding eigenvalues and eigenvectors*, complex eigenvalues, eigenvalues and singular matrices, eigenvalues of inverse

3. 8.9: Powers of Matrices- *Cayley Hamilton theorem*, ^inding theinverse

4. 8.10: Orthogonal Matrices- symmetric matrices and eigenvalues, inner product, *criterion for* orthogonal matrix, construction of orthogonalmatrix

5. 8.12: Diagonalization- diagonalizable matrix -*suf#icient conditions*, orthogonal diagonalizability *of symmetric matrix*, Quadratic Forms

References:

1. Soo T Tan: Calculus *Brooks/Cole, Cengage Learning (2010) ISBN 0-534-46579-X*
2. Gilbert Strang: Calculus *Wellesley Cambridge Press (1991) ISBN:0-9614088-2-0*
3. Ron Larson. Bruce Edwards: Calculus(11/e) *Cengage Learning (2018) ISBN: 978-1- 337-27534-7*
4. Robert A Adams & Christopher Essex: Calculus *Single Variable (8/e) Pearson Education Canada (2013) ISBN:* 0321877403
5. Joel Hass, Christopher Heil & Maurice D. Weir: Thomas' Calculus(14/e) *Pearson (2018) ISBN 0134438981*
6. Peter V O'Neil: Advanced Engineering Mathematics(7/e) *Cengage Learning (2012) ISBN: 978-1-111-42741-2*
7. Erwin Kreyszig: Advanced Engineering Mathematics(10/e) *John Wiley & Sons (2011) ISBN: 978-0-470-45836-5*
8. Glyn James: Advanced Modern Engineering Mathematics(4/e) *Pearson Education Limited (2011) ISBN: 978-0-273-71923-6*

Text:

1. Calculus I (2/e): Jerrold Marsden & Alan Weinstein *Springer-Verlag New York Inc (1985) ISBN 0-387-90974-5*
2. Calculus II (2/e): Jerrold Marsden & Alan Weinstein *Springer-Verlag New York Inc (1985) ISBN 0-387-90975-3*
3. Advanced Engineering Mathematics(6/e): Dennis G Zill *Jones & Bartlett Learning, LLC (2018) ISBN: 978-1-284-10590-2*

Complementary Course

Semester - 3

MT3 C03 MATHEMATICS - 3

Number of Credits: 3

Contact Hours per week: 5

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **21 Hours**

1. 9.1: Vector Functions – Vector-Valued Functions, Limits, Continuity, and Derivatives, Geometric Interpretation of $r(t)$, Higher-Order Derivatives, Integrals of Vector Functions, Length of a Space Curve, Arc Length as a Parameter

2. 9.2: Motion on a Curve-Velocity and Acceleration, Centripetal Acceleration, Curvilinear Motion in the Plane

3. 9.3: Curvature and components of Acceleration- *definition*, *Curvature of a Circle,* Tangential and Normal Components of Acceleration, The Binormal, Radius of Curvature

4. 9.4: Partial Derivatives-Functions of Two Variables, Level Curves, Level Surfaces, Higher-Order and Mixed Derivatives, Functions of Three or More Variables, Chain Rule, Generalizations

5. 9.5: Directional Derivative-The Gradient of a Function, A Generalization of Partial Differentiation, Method for Computing the Directional Derivative, Functions of Three Variables, Maximum Value of the Directional Derivative, Gradient Points in Direction of Most Rapid Increase of f

6. 9.6: Tangent planes and Normal Lines-Geometric Interpretation of the Gradient, Tangent Plane, Surfaces Given by $z = f(x, y)$, Normal Line

Module 2 **24 Hours**

1. 9.7: Curl and Divergence - Vector Fields, *definition of curl and divergence*, Physical Interpretations

2. 9.8: Line Integrals - *definition* of smooth *closed and simple closed curves*, Line Integrals in the Plane, Method of Evaluation-curve as explicit function and curve given parametrically, Line Integrals in Space, Method of Evaluation, Work, Circulation

3. 9.9: Independence of Path- Conservative Vector Fields, Path Independence, A Fundamental

Theorem, de*finition of connected, simply connected and multiconnected regions,* Integrals Around Closed Paths, Test for a Conservative Field, Conservative Vector Fields in 3-Space, Conservation of Energy

4. 9.10: Double Integral- Integrability, Area, Volume, Properties, Regions of Type I and II, Iterated Integrals, Evaluation of Double Integrals (*Fubini theorem*), Reversing the Order of Integration, Laminas with Variable Density—Center of Mass, Moments of Inertia, Radius of Gyration

5. 9.11: Double Integrals in Polar Coordinates- Polar Rectangles, Change of Variables: Rectangular to Polar Coordinates,

6. 9.12: Green's Theorem- Line Integrals Along Simple Closed Curves, *Green's theorem in plane,* Region with Holes,

7. 9.13: Surface Integral- Surface Area, Differential of Surface Area, Surface Integral, Method of Evaluation, Projection of *S* into Other Planes, Mass of a Surface, Orientable Surfaces, Integrals of Vector Fields-*Flux,*

8. 9.14: Stokes's Theorem- Vector Form of Green's Theorem, Green's Theorem in 3- Space-*Stokes' Theorem*, Physical Interpretation of Curl

Module 3 **21 Hours**

1. 9.15: Triple Integral definition, Evaluation by Iterated Integrals, Applications, Cylindrical Coordinates, Conversion of Cylindrical Coordinates to Rectangular Coordinates, Conversion of Rectangular Coordinates to Cylindrical Coordinates, Triple Integrals in Cylindrical Coordinates, Spherical Coordinates, Conversion of Spherical Coordinates to Rectangular and Cylindrical Coordinates, Conversion of Rectangular Coordinates to Spherical Coordinates, Triple Integrals in Spherical Coordinates

2. 9.16: Divergence Theorem- Another Vector Form of Green's Theorem, *divergence or Gauss' theorem, (proof omitted),* Physical Interpretation of Divergence

3. 9.17: Change of Variable in Multiple Integral- Double Integrals, Triple Integrals

4. 17.1: Complex Numbers- definition, arithmetic operations, conjugate, Geometric Interpretation

5. 17.2: Powers and roots-Polar Form, Multiplication and Division, Integer Powers of *z*, De-Moivre's Formula, Roots

6. 17.3: Sets in the Complex Plane- *neighbourhood, open sets, domain, region etc.*

7. 17.4: Functions of a Complex Variable- *complex functions*, Complex Functions as Flows, Limits and

Continuity, Derivative, Analytic Functions – *entire functions*

8. 17.5: Cauchy Riemann Equation- A Necessary Condition for Analyticity, *Criteria for analyticity,* Harmonic Functions, Harmonic Conjugate Functions,

9. 17.6: Exponential and Logarithmic function- (Complex)Exponential Function, Properties, Periodicity, *('Circuits' omitted), Complex Logarithm-principal value, properties*, Analyticity

10. 17.7: Trigonometric and Hyperbolic functions- Trigonometric Functions, Hyperbolic Functions, Properties -*Analyticity, periodicity, zeros etc.*

Module 4 **15 Hours**

1. 18.1: Contour integral- *definition*, Method of Evaluation, Properties, *ML*- inequality. Circulation and Net

2. 18.2: Cauchy-Goursat Theorem- Simply and Multiply Connected Domains, Cauchy's Theorem, *Cauchy–Goursat theorem*, Cauchy–Goursat Theorem for Multiply Connected Domains,

3. 18.3: Independence of Path- *Analyticity and path independence*, *fundamental theorem for contour integral, Existence of Antiderivative*

4. 18.4: Cauchy's Integral Formula- First Formula, Second Formula-*C.I.F. for derivatives*. Liouville's Theorem, Fundamental Theorem of Algebra

References:

1. Soo T Tan: Calculus *Brooks/Cole, Cengage Learning (2010) ISBN 0-534- 46579-X*
2. Gilbert Strang: Calculus *Wellesley Cambridge Press (1991) ISBN:0-9614088-2- 0*
3. Ron Larson. Bruce Edwards: Calculus(11/e) *Cengage Learning (2018) ISBN: 978-1-337-27534-7*
4. Robert A Adams & Christopher Essex: Calculus *several Variable (7/e)*
5. Jerrold Marsden & Anthony Tromba: Vector Calculus (6/e) *W. H. Freeman and Company ISBN 978-1-4292-1508-4*
6. Peter V O'Neil: Advanced Engineering Mathematics(7/e) *Cengage Learning (2012) ISBN: 978-1-111-42741-2*
7. Erwin Kreyszig: Advanced Engineering Mathematics(10/e) John Wiley & Sons (2011) ISBN: 978-0-470-45836-5
8. Glyn James: Advanced Modern Engineering Mathematics(4/e) Pearson Education Limited (2011) ISBN: 978-0-273-71923-6

Text:

1. Advanced Engineering Mathematics(6/e): Dennis G Zill *Jones & Bartlett Learning, LLC (2018) ISBN: 978-1-284-10590-2*

Complementary Course

Semester - 4

MT4 C04 MATHEMATICS - 4

Number of Credits: 3

Contact Hours per week: 5

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **2 Hours**

Ordinary Differential Equations

1. 1.1: Definitions and Terminology- definition, Classification by Type, Classification by Order, Classification by Linearity, Solution, Interval of Definition, Solution Curve, Explicit and Implicit Solutions, Families of Solutions, Singular Solution, Systems of Differential Equations
2. 1.2: Initial Value Problems-First- and Second-Order IVPs, *Existence of solution*
3. 1.3: Differential Equations as Mathematical Models- *some specific differential- equation models in biology, physics and chemistry.*
4. 2.1: Solution Curves without Solution-Direction Fields *[‘Autonomous First- Order DEs’ omitted]*
5. 2.2: Separable Equations- definition. Method of solution, losing a solution, An Integral- Defined Function
6. 2.3: Linear Equations- definition, standard form, homogeneous and non homogeneous DE, *variation of parameter technique,* Method of Solution, General Solution, Singular Points, Piecewise-Linear Differential Equation, Error Function
7. 2.4: Exact Equations- Differential of a Function of Two Variables**,** *Criteria for an exact differential,* Method of Solution, Integrating Factors,
8. 2.5: Solutions by Substitution-Homogeneous Equations, Bernoulli’s Equation, Reduction to Separation of Variables
9. 2.6: A Numerical Method- Using the Tangent Line, Euler’s Method *[up to and including Example 2; rest omitted]*

Module 2 **22 Hours**

Higher Order Differential Equations

1. 3.1: Theory of Linear Equations- Initial-Value and Boundary-Value Problems [Existence and Uniqueness *(of solutions),* Boundary-Value Problem]

   Homogeneous Equations [Differential Operators, Superposition Principle, Linear Dependence and Linear Independence, Wronskian]

   Nonhomogeneous Equations [Complementary Function, Another Superposition Principle]

2. 3.2: Reduction of Order- *a general method to find a second solution of linear second order equation by reducing to linear first order equation*

3. 3.3: Homogeneous Linear Equations with Constant Coefficients- Auxiliary Equation, *Distinct Real Roots*, *Repeated Real Roots*, *Conjugate Complex Roots,* Higher- Order Equations, Rational Roots *['Use of computer' part omitted]*

4. 3.4: Undetermined Coefficients- Method of Undetermined Coefficients for finding out particular solution

5. 3.5: Variation of parameter- *General solution using Variation of parameter technique*

6. 3.6: Cauchy-Euler Equations- Method of solution, *Distinct Real Roots, Repeated Real Roots, Conjugate Complex Roots*

7. *3.9:* Linear Models & Boundary Value Problems- Deflection of a Beam, Eigenvalues and *Eigenfunctions [up to and including Example 3: the rest is omitted]*

Module 3 **19 Hours**

Laplace Transforms

1. 4.1: Definition of Laplace Transform- *definition, examples, linearity, Transforms of some basic functions,* Sufficient Conditions for Existence of transform,

2. 4.2: Inverse Transform and Transforms of Derivative- Inverse Transforms: *A few important inverse transforms,* Linearity, Partial Fractions, Transforms of Derivatives, Solving Linear ODEs

3. 4.3: Translation Theorems- Translation on the *s*-axis, *first translation theorem*, *its inverse form*, Translation on the *t*-axis, Unit step function, second translation theorem. *Its Inverse form*, Alternative Form of second translation theorem. Beams

4. 4.4: Additional Operational Properties- Derivatives of Transforms**,** Transforms of Integrals-

convolution, *convolution theorem (without proof) and its inverse form,* Volterra Integral Equation, Series Circuits *[*'Post Script— Green's Function Redux' *omitted],* Transform of a Periodic Function

5. 4.5: The Dirac delta Function- Unit Impulse, The Dirac Delta Function *and its transform,*

Module 4 **18 Hours**

1. 12.1: Orthogonal Functions- Inner Product, Orthogonal Functions, Orthonormal Sets, Vector Analogy, Orthogonal Series Expansion, Complete Sets,
2. 12.2: Fourier Series-Trigonometric Series, Fourier Series, Convergence of a Fourier Series, Periodic Extension, Sequence of Partial Sums,
3. 12.3: Fourier Cosine and Sine Series- Even and Odd Functions., Properties, Cosine and Sine Series, Gibbs Phenomenon, Half-Range Expansions, Periodic Driving Force,
4. 13.1: Separable Partial Differential Equations- Linear Partial Differential Equation, Solution of a PDE, Separation of Variables (*Method*), Superposition Principle, Classification of Equations (-*hyperbolic, parabolic, elliptic)*
5. 13.2: Classical PDE's and BVP's**-** Heat Equation, Wave Equation, Laplace's Equation, Initial Conditions, Boundary Conditions, Boundary-Value Problems *('Variations' omitted)*
6. 13.3: Heat Equation- Solution of the BVP **(***method of Separation of Variables***)**

References:

1. Peter V O'Neil: Advanced Engineering Mathematics(7/e) *Cengage Learning (2012) ISBN: 978-1-111-42741-2*
2. Erwin Kreyszig: Advanced Engineering Mathematics(10/e) *John Wiley & Sons (2011) ISBN: 978-0-470-45836-5*
3. Alan Jeffrey: Advanced Engineering Mathematics *Harcourt/ Academic Press (2002) ISBN: 0-12-382592-X*
4. Glyn James: Advanced Modern Engineering Mathematics(4/e) Pearson Education Limited (2011) ISBN: 978-0-273-71923-6

Text:

1. Advanced Engineering Mathematics(6/e): Dennis G Zill *Jones & Bartlett Learning, LLC (2018) ISBN: 978-1-284-10590-2*

Complementary Course

Semester - 1

ME1 C01 MATHEMATICAL ECONIMICS

Number of Credits: 3

Contact Hours per week: 4

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 (Text 1) **18 Hours**

Demand and Supply Analysis

Utility and Demand-the meaning of demand and quantity demanded-the law of demand-demand curve-market demand curve-reasons for the law of demand-slope of a demand curve-shift in demand-demand function and demand curve-the meaning of supply-supply function-law of supply-slope of a supply curve-shift in supply-market equilibrium-price elasticity of demand-measurement of price elasticity-arc elasticity of demand-cross elasticity of demand

(relevant sections of chapter 5 and 7)

Module 2 (Text 1) **18 Hours**

Cost and Revenue Functions

Cost function-Average and marginal cost – short run and long run costs-shapes of average cost curves in the short run and long run and its explanation-revenue function, marginal revenue (MR) and average revenue functions (AR), relations between MR, AR and elasticity of demand

(relevant sections of chapter 19 and 21)

Module 3

Theory of Consumer Behavior

Cardinal utility analysis-the law of diminishing marginal utility- the law of equi-marginal utility-indifference curves-ordinal utility-indifference map-marginal rate of substitution- properties of indifference curves

(Relevant sections of chapter 9 and 11)

Module 4 (Text 2) **20 Hours**

Economic Applications of Derivatives

Economic Applications of Derivatives-Marginal, average and total concepts-optimizing economic functions-Functions of several variables and partial derivatives-rule of partial differentiation, second order partial derivatives, Optimization of multivariable functions, constrained optimization with Lagrange multipliers, significance of Lagrange multiplier, total and Partial derivatives-total derivatives

Marginal productivity, Income determination, multipliers and comparative statics, Income and cross elasticity of demand, Optimization of multivariable function in Economics, constrained optimization of multivariable function in Economics

(Chap-4: sec. 4.7 & 4.8; Chap-5, chap-6: sec.6.1 to 6.6)

References:

1. R G D Allen: Mathematical Analysis for Economists *Macmillain*
2. Geoff Renshaw: Maths for Economics(3/e) *Oxford University Press, N.Y. (2012) ISBN 978–0–19–960212–4*
3. Mike Rosser: Basic Mathematics for Economists(2/e) *Routledge, London (2003) ISBN 0–415–26784–6*
4. Taro Yamane: Mathematics for Economists *An Elementary Survey Prentice Hall Inc. (1962)*
5. Knut Sydsæter and Peter Hammond: Essential Mathematics for Economic Analysis(4/e) *Pearson Education Limited (2012)*
6. Henderson & Quandt: Microeconomic Theory A Mathematical Approach (3/e) *TMH*

Text:

1. H.L. Ahuja: Principles of Micro Economics, *15th Revised Edition, S. Chand*
2. Edward T. Dowling: Introduction to Mathematical Economics, *Schaum's Outline Series, Third edition, TMH*

Complementary Course

Semester - 2

ME2 C02 MATHEMATICAL ECONIMICS

Number of Credits: 3

Contact Hours per week: 4

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 (Text 1) **9 Hours**

Inequalities in Income

Inequalities in Income-Causes of inequalities, Measures to reduce inequality, Measurement of inequality of income- Lorenz curve, Gini ratio. **(Chapter 47)**

Module 2 (Text 2) **18 Hours**

Chapter 14: Calculus of Several Variable

Directional Derivatives and Gradients, *the gradient vector*, Explicit functions from R^n to R^m , *Approximation by Differentials, Jacobian derivative, The Chain rule,* Higher Order Derivative. Continuously differentiable functions, *Second order derivatives and Hessians, Young's theorem, An economic application*

Chapter 17: Unconstrained Optimization

Definitions, First Order Conditions, Second Order Conditions, *sufficient conditions, necessary conditions,* Global Maxima and Minima, *Global Maxima of Concave Functions,* Economic Applications, *profit maximizing firm, discriminating monopolist, least squares analysis*

(Sec. 14.6,14.7,14.8, 17.1,17.2,17.3,17.4,17.5)

Module 3 (Text 2) **18 Hours**

Chapter 18 Constrained Optimization I: First Order Conditions

Objective function, constraint functions, Examples, Equality Constraints, *two variables and one equality constraint, several equality constraints,* inequality constraints, *one inequality constraint, several inequality constraints,* Mixed Constraints, Constrained Minimization Problems, Kuhn-Tucker Formulation, Examples and Applications,

(Sec. 18.1,18.2,18.3,18.4,18.5,18.6,18.7)

Module 4 (Text 3) **19 Hours**

Input Output Analysis

Introduction – assumption-technological coefficient matrix-closed and open input output model-coefficient matrix and open model-the Hawkins-Simon conditions-solutions for two industries- determination of equilibrium of prices- coefficient matrix and closed model- The Leontief production function-limitation of input output analysis

(sec.19.1 to 19.7, 19.9,19.11,19.13)

References:

1. A C Chiang & K Wainwright: Fundamentals of Mathematical Economics (4/e) *McGraw Hill*
2. R G D Allen: Mathematical Analysis for Economists *Macmillain*
3. Urmila Diwekar: Introduction to Applied Optimization(2/e) *Springer Science+Business Media, LLC (2008) ISBN: 978-0-387-76634-8*
4. Michael D Intriligator: Mathematical Optimization and Economic Theory *Classics in Applied Mathematics, SIAM (2002)*
5. Akinson: Distribution and Inequality Measures *TMH*

Text:

1. M L Jhingan: Micro Economic Theory(6/e) *Vrinda Publications*
2. Carl P Simon, Lawrence Blume: Mathematics for Economists *W. W.Norton & Company, Inc (1994) ISBN 0-393-95733-O*
3. Mchta-Madnani: Mathematics for Economics *Revised Edn S Chand*

Complementary Course

Semester - 3

ME3 C03 MATHEMATICAL ECONIMICS

Number of Credits: 3

Contact Hours per week: 5

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1(Text 1) **22 Hours**

Differential and Difference Equations

Differential Equations- definitions and concepts, First Order Linear Differential Equations, Exact differential equations-integrating factors, separation of variables, Economic applications, - use of differential equations in economics

Difference Equations- definitions and concepts, First Order Linear Difference Equations, Economic applications-the Cobweb model, the Harrod model

(Chapter 16,17)

Module 2

The Production Function

Meaning and nature of production function, the law of variable proportions- isoquants marginal rate of technical substitution (MRTs), producer's equilibrium, Expression path, The elasticity of substitution, Ridge kines and economic region of production

(Chapter 14 Sec. 14.1 to 14.9)

Module 3 (Text 1 & 2) **18 Hours**

Euler's theorem (statement only), Euler's theorem and homogeneous production function, Cobb Douglas production function, properties Economic significance, Limitations, CES production function, -properties – advantages-limitations, returns to scale, cobweb theorem

(Chapter 14 Sec. 14.10 to 14.13 of text (2))

Optimization of Cobb Douglas production function, Optimization of constant elasticity of production function

(Chapter 6 Sec. 6.9 & 6.10 of text (1))

Module 4 (Text 3) **22 Hours**

Investment Decisions and Analysis of Risks

Nature of investment decisions, appraisal necessary, Needed information, Appraisal techniques Pay back method, Average rate of return (ARR) method, Net Present Value(NPV) method, Internal Rate of Return (IRR) Method, Net Terminal Value Method, Profitability index(P.I.) Analysis of Risk/Uncertainty; The Risk concept, Risk and Uncertainty situations, Measurement of Risks in precise terms, Incorporating risk in Investment Decisions, Risk adjusted discount rate(RAD) approach, Certainty- Equivalent approach, Probability Distribution approach(The Hillier Models), Decision Trees Approach, Simulation Approach,(Hertz's model) Sensitivity analysis **(Chapter 16)**

References:

1. A C Chiang & K Wainwright: Fundamentals of Mathematical Economics (4/e) *McGraw Hill*
2. R G D Allen: Mathematical Analysis for Economists *Macmillain*
3. Srinath Baruah: Basic Mathematics and its Applications in Economics *Macmillian*
4. Taro Yamane: Mathematics for Economists *An Elementary Survey Prentice Hall Inc. (1962)*

Text:

1. Edward T. Dowling: Introduction to Mathematical Economics, *Schaum's Outline Series, Third edition, TMH*
2. S P Singh, A P Parashar, H P Singh: Econometrics and Mathematical Economics *S. Chand*
3. C R Kothari: An Introduction to Operation Research (3/e) *Vikas Pub. House*

Complementary Course

Semester - 4

ME4 C04 MATHEMATICAL ECONIMICS

Number of Credits: 3

Contact Hours per week: 5

Course Evaluation: Internal – 15 Marks + External – 60 Marks

Course Outline

Module 1 **18 Hours**

Introduction to Econometrics-The nature of Regression Analysis-Two variable Regression Analysis

(pages 1 to 59 of Text)

Module 2 **22 Hours**

Two variable Regression Model **(sec. 3.1 to 3.9; pages 60 to 103)**

Module 3 **22 Hours**

Classical normal linear regression model-two variable Regression-Internal Estimation and hypothesis testing,

(sec. 4.1 to 4.5 and 5.1 to 5.13)

Module 4 **18 Hours**

Extensions of the two variable linear regression model **(sec. 6.1 to 6.10)**

References:

1. Jeffrey M. Wooldridge: Introductory Econometrics: A Modern Approach (6/e) *Cengage Learning (2016)*
2. S P Singh, A P Parashar, H P Singh: Econometrics and Mathematical Economics *S. Chand*
3. Douglas C. Montgomery, Elizabeth A. Peck, Geoffrey Vining: Introduction to Linear Regression Analysis (5/e) *John Wiley & Sons (2012)*
4. Christopher Dougherty: Introduction to Econometrics(3/e) *Oxford University Press (2007)*

Text:

1. Damodar N Gujarati & Sangeetha: Basic Economics(4/e) *TMH Indian Reprint 2008*