SOMAIYA VIDYAVIHAR
K J Somaiya College of Science & Commerce
Autonomous (Affiliated to University of Mumbai)

Somaiya TRUST

Board of studies in Mathematics
Undergraduate (S.Y.B.Sc., S.Y.B.Com., T.Y.B.Sc. and T.Y.B.Com.)

	Name	Designation	Institute/Industry
Head of the Department			
1	Subhash Krishnan	Chairperson	K.J. Somaiya College of Science and Commerce
Subject Expert nominated by Vice-Chancellor			
1	Dr. Jyotshana Prajapat	Professor	University of Mumbai
Subject experts			
1	Dr. Ravi Rao	Professor	NMIMS
2	Dr. Dhvanita Rao	Associate Professor (retired)	Bhavans College
3	Dr. Shripad Garge	Assistant Professor	IITM
4	Mrs. Urmilla Pillai	Associate Professor	CHM College
5	Mr. Nimesh G. Punjani	Assistant Professor	Lala Lajpatrai College
Representative from Industry/corporate sector/allied area			
1	Mr. Ananthkrishnan Subramanian	Director, Program management	Zeotap
Meritorious Alumnus			
1	Mr. Sudhir Kumar Thakur	Jr. College lecturer	S. I. E. S College
Faculty of the specialisation			
1	Mrs. Sudha Agrawal	Associate Professor	K.J. Somaiya College of Science and Commerce
2	Dr. (Mrs.) Reema Khanna	Associate Professor	K.J. Somaiya College of Science and Commerce
3	Mr. Makarand Niphadkar	Assistant Professor	K.J. Somaiya College of Science and Commerce
4	Mr. Prabhat Kumar Upadhyay	Assistant Professor	K.J. Somaiya College of Science and Commerce

S.Y. B. Sc. (Mathematics) SEMESTER III
Core Course- I
COURSE TITLE: Real Analysis - II
COURSE CODE: 22US3MTCC1ANL [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to: 1: Apply results proved to solve problems on continuity 2: Apply established results on Riemann Integration 3: Apply the consequences of Riemann Integration		
Module 1	Continuity and Uniform Continuity over *R*	[12L]
Learning Objective: This module is intended to 1. Learn the concepts of continuity and uniform continuity and their immediate consequences		
Learning Outcomes: After the successful completion of the module, the learner will be able to 1. Solve problems of continuity using sequential criterion 2. Solve problems of uniform continuity 3. Distinguish between continuous and uniform continuous functions 4. Prove theorems such as Nested Interval Property, Intermediate Value Property and related results 5. Apply results proved to solve problems		
1.1	Review of continuous functions and sequences	[1L]
1.2	Sequential criterion for continuity and its equivalence with the $\varepsilon - \delta$ definition. Continuous image of a Cauchy sequence need not be Cauchy	[3L]
1.3	Uniformly continuous functions. Monotonic function defined on a closed and bounded interval is uniformly continuous. Uniformly continuous image of a Cauchy sequence is Cauchy	[4L]
1.4	Nested Interval Property Proof of Intermediate Value Property. Proof of maximum value property of continuous functions on a closed and	[4L]

	bounded interval. Continuous function on a closed and bounded interval is uniformly continuous	

References:

- R.G. Bartle and D. R Sherbert; Introduction to Real Analysis; John Wiley and Sons (Asia) P.Ltd.
- R. R. Goldberg; Methods of Real Analysis; Oxford and IBH.
- Ajit Kumar, S. Kumaresan; A Basic Course in Real Analysis; CRC Press.
- Ghorpade, Sudhir R., Limaye, Balmohan V.; A Course in Calculus and Real Analysis; Springer.

Additional Reference books:

- H. Anton, I. Bivens and S. Davis; Calculus; John Wiley and Sons, Inc
- G.B. Thomas and R.L. Finney; Calculus; Pearson Education.
- T. M. Apostol; Calculus (Vol. I); John Wiley and Sons (Asia) P. Ltd.
- W. Rudin; Principles of mathematical Analysis; Tata McGraw- Hill Education.
- Maron; Calculus of one variable.
- Shanti Narayan and Raisinghania; Elements of Real Analysis; S. Chand

Module 2	Riemann Integration	[12L]

Learning Objectives:

This module is intended to:

1. Understand the concept of Riemann integration
2. Enable the learner to solve problems using definitions
3. Prove the properties of Riemann integration
4. Apply the properties of Riemann integration

Learning outcomes:

After the successful completion of the module, the learner will be able to

1. Solve problems using definitions and properties
2. Prove the properties of Riemann integration

2.1	Partition of a set, partition of an interval in a finite number of subintervals. Upper Riemann sum and lower Riemann sum of a function with respect to a partition	[3L]

2.2	Upper integral, lower integral of a function. Definition of Riemann integrability and integral of a function over an interval. Simple examples	[3L]
2.3	Riemann criterion for integrability with examples.Basic properties of Riemann integrable (R-integrable) functions. Monotonic functions over a closed and bounded interval are R-integrable. Continuous functions defined over a closed and bounded interval are R- integrable. R- integrability of piecewise continuous functions over bounded intervals	[6L]

References:

- R.G. Bartle and D. R Sherbert; Introduction to Real Analysis; John Wiley and Sons (Asia) P.Ltd.
- R. R. Goldberg; Methods of Real Analysis; Oxford and IBH.
- Ajit Kumar, S. Kumaresan; A Basic Course in Real Analysis; CRC Press.
- Ghorpade, Sudhir R., Limaye, Balmohan V.; A Course in Calculus and Real Analysis; Springer.

Additional Reference books:

- H. Anton, I. Bivens and S. Davis; Calculus; John Wiley and Sons, Inc.
- G.B. Thomas and R.L. Finney; Calculus; Pearson Education.
- T. M. Apostol; Calculus (Vol. I); John Wiley and Sons (Asia) P. Ltd.
- W. Rudin; Principles of mathematical Analysis; Tata McGraw- Hill Education.
- Maron; Calculus of one variable.
- Shanti Narayan and Raisinghania; Elements of Real Analysis; S. Chand

Module 3	Fundamental Theorem of Calculus and Applications of Riemann Integration	[12L]

Learning Objectives:

This module is intended to

1. Prove the Fundamental Theorem of Calculus
2. Apply the Fundamental Theorem of Calculus
3. Study other applications of Riemann integration

Learning outcomes:

After the successful completion of the module, the learner will be able to

1. Prove the Fundamental Theorem of Calculus
2. Apply the Fundamental Theorem of Calculus to solve problems
3. Apply the results on Riemann integration

4. Solve problems on convergence of Improper integrals 5. Solve problems related to beta and Gamma functions		
3.1	Fundamental theorems of calculus and applications	[3L]
3.2	Integration by parts, Change of variable formula, Mean Value theorem for integrals	[2L]
3.3	Computation of area under a curve, area of bounded regions.	[1L]
3.4	Volume of regions obtained by rotating a curve about an axis.	[2L]
3.5	Improper integrals and their convergence, Beta and Gamma functions, Duplication Formula, properties related to Beta and Gamma functions	[4L]

References:

- R.G. Bartle and D. R Sherbert; Introduction to Real Analysis; John Wiley and Sons (Asia) P.Ltd.
- R. R. Goldberg; Methods of Real Analysis; Oxford and IBH.
- Ajit Kumar, S. Kumaresan; A Basic Course in Real Analysis; CRC Press
- Ghorpade, Sudhir R., Limaye, Balmohan V.; A Course in Calculus and Real Analysis; Springer.

Additional Reference books:

- H. Anton, I. Bivens and S. Davis; Calculus; John Wiley and Sons, Inc.
- G.B. Thomas and R.L. Finney; Calculus; Pearson Education.
- T. M. Apostol; Calculus (Vol. I); John Wiley and Sons (Asia) P. Ltd.
- W. Rudin; Principles of mathematical Analysis; Tata McGraw- Hill Education.
- Maron; Calculus of one variable.
- Shanti Narayan and Raisinghania; Elements of Real Analysis; S. Chand

Question Paper Template
S.Y. B. Sc. (Mathematics) SEMESTER III
Core Course- I
COURSE TITLE: Real Analysis - II
COURSE CODE: 22US3MTCC1ANL [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	2	10	3	10	-	5	30
II	2	5	3	10	5	5	30
III	2	5	3	10	10	-	30
Total marks per objective	6	20	9	30	15	10	90
% Weightage	6.7%	22.2%	10%	33.3%	16.7%	11.1 %	100

S.Y. B. Sc. (Mathematics) SEMESTER III
Core Course- II
COURSE TITLE: Linear Algebra - I
COURSE CODE: 22US3MTCC2LA [CREDITS – 02]

Course Learning Outcome	
After the successful completion of the Course, the learner will be able to:	
1:	Solve given system of linear equations using Gauss Elimination method.
2:	Verify properties of a vector space.
3:	Apply properties of an inner product space to solve problems.
The entire course is emphasised on finitely generated real vector spaces.	

Module 1	Matrices and System of Linear Equations	[9L]

Learning Objectives:

This module is intended to

1. Learn the various types of matrices, operations on matrices, their properties
2. Concept of System of Linear equations, methods to solve them with the geometric interpretation, followed by their simple applications

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Solve problems based on Matrices and their properties
2. Solve problems based on system of linear equations by Gauss Elimination method
3. Interpret geometrically the system and its solution
4. Prove the results related to matrices and system of linear equations.

1.1	Matrices over ℂ, types of matrices, addition, and multiplication of matrices and their properties, transpose and inverse of a matrix.	[2L]
1.2	Introduction to system of linear equations, homogeneous and non-homogeneous system, solution of a system, consistent and inconsistent system, equivalent systems. Homogeneous system with m equations in n unknowns has a non-trivial solution if m<n.	[3L]
1.3	Matrix representation of a system of linear equations, Elementary row operations, row echelon form, Gauss Elimination method to solve system of linear equations, geometric interpretation of a system and its solution upto three variables.	[4L]

References:

- S. Kumareson -Linear algebra: A geometric approach
- K Hoffman and R Kunze - Linear algebra
- I.K. Rana – Linear algebra
- Schaum's outline series – Linear algebra
- Schaum's outline series – Matrices

Additional Reference books:

- Gilbert Strang – Linear Algebra
- Serge Lang – Linear Algebra

Module 2	Vector Spaces	[18L]

Learning Objectives:

This module is intended to

1. Understand the concept of vector space and subspace
2. Enable the learner to test the linear independence and generating property

3. Prove the results related to various concepts of a vector space

Learning outcomes:

After the successful completion of the module, the learner will be able to

1. Solve problems related to various concepts in vector spaces using definitions and properties
2. Prove the properties in a vector space related to basis, dimension and rank of a matrix
3. Describe subspaces of IR^2 and IR^3, finding basis of a subspace
4. Find rank of a matrix

2.1	Vector space over, simple examples including IR^n, ℂ, $M_{mn}(IR)$, $P_n(x)$, C[a,b] under usual operations. (Emphasis only on real vector spaces)	[2L]
2.2	Subspaces, necessary and sufficient condition for a subset to form a subspace, intersection and sum of subspaces. Simple examples.	[3L]
2.3	Linear combination and linear span, Linearly independent and dependent set, generating set, finitely generated vector space, basis, co-ordinates of a vector.	[4L]
2.4	Maximal linearly independent set and minimal generating set, their equivalence with basis, extension/reduction of a given subset to a basis. Dimension of a vector space, a set containing n+1 vectors is linearly dependent in an n dimensional vector space, describing subspaces of ^{2} and ^{3}	[5L]
2.5	Direct sum of subspaces, related results, dimension of direct sum in terms of the dimensions of subspaces.	[2L]
2.6	Row space and Column Space of a matrix, Row rank and Column rank and their equivalence, rank of a matrix. Computing rank of a matrix by row reduction and as dimension of row/column space.	[2L]

References:

- S. Kumareson; Linear algebra : a geometric approach
- K Hoffman and R Kunze ; Linear algebra
- I.K.Rana; Linear algebra
- Schaum's outline series; Linear algebra

Additional Reference books:

- Gilbert Strang – Linear Algebra
- Serge Lang – Linear Algebra

Module 3	Inner Product Spaces	[12L]
Learning Objectives: This module is intended to 1. Understand an inner product and norm induced by it 2. Establish various identities involving norm and inner product 3. Learn Gram Schmidt process 4. Understand orthogonal complement of a subspace		
Learning outcomes: After the successful completion of the module, the learner will be able to 1. Test if given map is an inner product 2. Establish various identities between inner product and norm 3. Solve problems using various identities 4. Find an orthonormal basis using Gram Schmidt process 5. Compute the orthogonal complement of a subspace		
3.1	Inner product space; definition and examples, Euclidean dot product as an inner product, Norm induced by inner product, Cauchy Schwarz inequality.	[3L]
3.2	Angle between two vectors, Orthogonal vectors, Pythagoras theorem, triangle inequality, parallelogram law and similar identities.	[2L]
3.3	Orthogonal projection of a vector, Orthogonal and orthonormal sets. Orthonormal basis, Gram-Schmidt orthogonalization process. Coordinates w.r.t. an orthonormal basis.	[2L]
3.4	Orthogonal complement of a subset, related results such as a vector space is direct sum of a subspace and its orthogonal complement.	[2L]
References: ● S. Kumareson -Linear algebra : a geometric approach ● K Hoffman and R Kunze - Linear algebra ● I.K.Rana – Linear algebra ● Schaum's Outline series – Linear algebra **Additional Reference books:** ● Gilbert Strang – Linear Algebra ● Serge Lang – Linear Algebra		

Question Paper Template
S.Y. B. Sc. (Mathematics) SEMESTER III
Core Course- II
COURSE TITLE: Linear Algebra - I
COURSE CODE: 22US3MTCC2LA [CREDITS – 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	3	5	5	5	5	-	23
II	5	10	10	10	5	5	45
III	-	-	10	2	10	-	22
Total marks per objective	8	15	25	17	20	5	90
% Weightage	8.8%	16.7%	27.7%	18.8%	22.2%	11.1 %	100%

SYBSC (MATHEMATICS) SEMESTER III
Core Course- III
COURSE TITLE: Graph Theory
COURSE CODE: 22US3MTCC3GRA [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to: 1: Generate graphs, its matrix representations or results based on different properties (defined or proved) and representations 2: Apply results proved on Trees for different requirements 3: Apply properties proved for special graphs like Eulerian, Hamiltonian and Planar graphs and graph colouring		
Module 1	Graphs, its representations and connectivity	[12L]
Learning Objectives: The module is intended to 1. Study types of graphs, relations between graphs and their properties. 2. Represent various types of graph 3. Associate graph theory to solve real-life problems		
Learning Outcomes: After the successful completion of the module, the learner will be able to 1. Define the basic concepts of graphs 2. Apply different situation using directed graphs, complete graphs etc 3. Decide connectivity for a given situation		
1.1	Simple graphs, Complete graphs, Regular graphs, subgraph, complement of a graph Walks, trails, paths, circuit, cycle, connected graph. Components of a graph, Bridge, cut vertex. Eulerian Graphs, Tree Special Graphs such as Wheel, Multipartite graphs, Directed graphs.	[2L]
1.2	Representation of graphs and Graph Isomorphisms: i) Adjacency matrix; Incident Matrix; Adjacency list ii) Isomorphisms of simple graphs.	[3L]
1.3	Number of walks in graph and its relationship with its adjacency matrix,	[3L]

	Triangles in a graph. Connectivity: i) Strongly connected and Weakly connected graphs ii) Shortest path problem: Dijkstra's algorithm	
1.4	Simple properties of graphs	[4L]

References:

- J. A. Bondy and U. S. R. Murty ; Graph theory with application; Springer (Freely downloadable)
- Reinhard Diestel; Graph Theory; Electronic edition Springer Verlag. (Freely downloadable)
- Narsingh Deo; Graph theory with application; Prentice Hall publication

Module 2	Trees	[12L]

Learning Objectives:

The module is intended to

1. Study different types of trees, their properties
2. Study various applications of trees especially in the field of Computer Science

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Identify type of tree
2. Find minimal spanning
3. Apply Concepts in various real-life situations
4. Prove basic results regarding trees

2.1	Trees, subtrees, Trees as models Rooted trees, m-ary trees. Tree traversal (preorder, inorder, post order)	[3L]
2.2	Application of Trees: Binary Search Trees, Locating and adding items to a Binary Search Tree. Decision Trees (simple examples). Game Trees, Minimax strategy and the value of a vertex in a Game Tree. Examples of games such as Nim and Tic-tac-toe. Spanning trees: Breadth first search trees, Depth first search Minimum Spanning trees: Prim’s Algorithm, Kruskal's algorithm	[5L]
2.3	Simple Properties related to trees	[4L]

References:

- J. A. Bondy and U. S. R. Murty ; Graph theory with application; Springer (Freely downloadable)
- Reinhard Diestel; Graph Theory; Electronic edition Springer Verlag. (Freely downloadable)
- Narsingh Deo; Graph theory with application; Prentice Hall publication

Module 3	Eulerian, Hamilton, Planar graphs and Colouring in a graph	[12L]

Learning Objectives:

The module is intended to

1. Study Eulerian, Hamitonian graphs
2. Find Chromatic number of planar graph
3. Find Chromatic polynomial of a planar graph

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Apply concept of Eulerian graph, Hamiltonian graph, planar graph
2. Solve different colourings of planar graphs
3. Find Chromatic polynomial of a planar graph
4. Prove results related to Eulerian graph, planar graph etc

3.1	Euler trail and circuits, Hamilton Paths and cycle. Konisberg 7 bridge problem.	[2L]
3.2	Introduction to edge colouring and vertex colouring in a simple graph. Vertex and edge chromatic number of a graph, Computation of the vertex and edge chromatic number. Brooks theorem (without proof), Vizing theorem (without proof)	[3L]
3.3	Planar graph and Euler formula, 5 colour theorem (without proof) four colour theorem (without proof). In any simple connected planar graphs having f regions, n vertices and e edges the following inequalities hold: If G is a simple planar graph with v$\geq$ 3, then e <3v – 6; If G is a simple planar graph, then $\delta \leq 5$. K_5 is nonplanar graph $K_{3,3}$ is a nonplanar graph.	[4L]
3.4	Chromatic polynomial of some simple graph such as trees, cycles, complete graph, wheel etc.	[3L]

References:

- J. A. Bondy and U. S. R. Murty ; Graph theory with application; Springer (Freely downloadable)
- Reinhard Diestel; Graph Theory; Electronic edition Springer Verlag. (Freely downloadable)
- Narsingh Deo; Graph theory with application; Prentice Hall publication

Question Paper Template
SYBSC (MATHEMATICS) SEMESTER III
Core Course- III
COURSE TITLE: Graph Theory
COURSE CODE: 22US3MTCC3GRA [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	2	8	10	-	5	5	30
II	2	8	10	-	5	5	30
III	2	8	5	5	5	5	30
Total marks per objective	6	24	25	5	15	15	90
% Weightage	6.67%	26.67%	27.78 %	5.55%	16.66%	16.67 %	100

S. Y. B. Sc. (Mathematics)
SEMESTER III - Practical
COURSE CODE: 22USCCMTP Credit- 02

Learning Objectives: The Practical is intended to 1. Solve problems based on the concepts learnt 2. Apply the concepts in various situation	
Learning Outcomes: After the successful completion of the practical, the learner will be able to 1. Solve problems 2. Apply the results proved 3. Generate examples and counterexamples	
Module I	Real Analysis-I
1.1 Sequential criterion for continuity	
1.2 Uniformly continuous, Intermediate Value Property	
1.3 Partition of an interval, Upper Riemann sum and lower Riemann sum, Upper integral, lower integral of a function.	
1.4 Riemann criterion for integrability, properties of Riemann integrable functions	
1.5 Fundamental theorems of calculus and application, Integration by parts, Change of variable formula, Mean Value theorem for integrals,	
1.6 Area of bounded regions. Volume of regions obtained by rotating a curve about an axis, improper integrals	
Module 2	Linear Algebra-I
2.1 Problems based on matrices, geometric interpretation of system of equations	
2.2 To find the solution set of given system of linear equations.	
2.3 Determine if the given set forms a vector space under given operations.	

2.4 To find a basis and dimension of a vector space.	
2.5 To find Rank of a matrix	
2.6 Properties of an inner product space, Gram Schmidt orthogonalization process.	
Module 3	Graph Theory
3.1 Drawing of graphs, matrix representation, isomorphism of graphs	
3.2 Dijkstra’s algorithm	
3.3 Tree traversal, binary search tree and game tree	
3.4 BFS, DFS trees, Kruskals and Prim’s algorithm	
3.5 Eulerian, Hamiltonian and Planar graphs	
3.6 Colouring and Chromatic polynomials	

S.Y. B. Sc. (Mathematics) SEMESTER IV
Core Course- I
COURSE TITLE: Ordinary differential equations
COURSE CODE: 22US4MTCC1ODE [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to: 1: Learn what is a first order differential equation and how to solve it. 2: Use various methods of solving second order differential equations 3: Apply theories to solve system of equations; simple ordinary differential equations using Laplace transformation		
Module 1	Differential equations of order 1	[12L]
Learning Objectives: The module is intended to: 1. Classify differential equations w.r.t. degree and order 2. Solve a differential equation by method of exact differential equations. 3. Solve linear and Bernoulli's differential equations. 4. Apply differential equations to some real-life problems.		
Learning Outcomes: After the successful completion of the module, the learner will be able to 1. Solve problems on ordinary differential equations of first order 2. Apply differential equations to problems related to microbiology, chemistry, physics		
1.1	Introduction to differential equations. Ordinary and partial differential equations. Examples of differential equations arising out of several situations. Forming a differential equation. Classification of differential equations on the basis of order, degree. Linear and nonlinear differential equations of a specified order. General solution and particular solution of a differential equation. First order differential equations in variables separable form. Homogeneous differential equations of order 1. Simple substitutions to convert a given first order differential equation to one of these forms Questions on 1.1 to be asked only in practical/internal exams and not in the end semester exam.	[3L]

1.2	Exact differential equations. Necessary and sufficient condition for a differential equation to be exact. Integrating factors. Rules for finding Integrating factors. Simple problems on computation of integrating factors to convert non exact differential equations to exact differential equations. (No theory questions expected)	[4L]
1.3	Linear differential equation of order 1. Establishing the formula to obtain its solution. Bernoulli's differential equation. Its solution by converting it to a linear differential equation.	[2L]
1.4	Applications of differential equations: Obtaining a family of curves orthogonal to a given family of curves. Exponential growth and decay. L-C circuits and R-L circuits.	[3L]

References:

- G. F. Simmons; Differential equations with Applications and Historical Notes; McGraw Hill Education

Additional Reference books:

- M.D. Raisinghania; Advanced Differential Equations; S. Chand Publications
- H. K. Dass; Higher Engineering Mathematics; S. Chand Publications

Module 2	Second order equations	[12L]

Learning Objectives:

The module is intended to

1. Solve problems on second order homogeneous differential equations.
2. Use Wronskian to generate basis of the space of solutions of a homogeneous.
3. Apply method of undetermined coefficients (UDC) and method of variation of parameters to solve nonhomogeneous differential equations.
4. Apply second order differential equations to solve real-life problems.

Learning outcomes:

After the successful completion of the module, the learner will be able to

1. Apply Wronskian to check linear independence of solutions of a differential equation.
2. Solve second order homogeneous differential equations.
3. Apply UDC method to find particular integral of a differential equation.

	4. Apply method of variation of parameters to find particular integral of a differential equation. 5. Apply ordinary differential equations of second order to problems related to astronomy and physics.	
2.1	The general second order linear differential equation. The linear differential equations with constant coefficients. Existence and Uniqueness Theorem for the solutions of a second order initial value problem (statement only).	[1L]
2.2	Homogeneous and non-homogeneous second order linear differential equations: The set of solutions of a homogeneous equation as a vector space. Linear dependence and linear independence of the solutions. Wronskian is either identically zero or it does not vanish anywhere in the domain. Use of Wronskian in deciding linear independence of solutions. The general solution of homogeneous differential equation. The use of known solutions to find the general solution of a homogeneous equations. The general solution of a non-homogeneous second order equation, Complementary functions and particular integrals.	[3L]
2.3	The homogeneous equation with constant coefficients, auxiliary equation, the general solution corresponding to real and distinct roots, real and equal roots and complex roots of the auxiliary equation. Non-homogeneous equations: The method of undetermined coefficients. The method of variation of parameters. Euler's equation and its solution by converting it to a linear differential equation with constant coefficients.	[4L]
2.4	Motion of a freely falling body under constant acceleration due to gravity neglecting the air resistance. Motion under constant gravitational force along with an air resistance proportional to the instantaneous velocity or to the square of instantaneous velocity. S.H.M. and Hook's Law. Simple problems on elastic strings and springs.	[4L]

References:

- G. F. Simmons; Differential equations with Applications and Historical Notes; McGraw Hill Education

Additional Reference books:

- M.D. Raisinghania; Advanced Differential Equations; S. Chand Publications
- H. K. Dass; Higher Engineering Mathematics; S. Chand Publications

Module 3	Linear Systems of first order differential equations and Laplace	[12L]

	Transforms	
Learning Objectives: This module is intended to 1. Study system of first order differential equations 2. Comprehend Laplace transforms and inverse Laplace transforms		
Learning outcomes: After the successful completion of the module, the learner will be able to 1. Evaluate Wronskian of a homogeneous system of first order differential equations 2. Evaluate general solution of homogeneous and nonhomogeneous system of first order differential equations 3. Prove properties of Laplace transforms 4. Apply Laplace transforms to solve differential equations		
3.1	System of first order differential equations. Linear System of two first order differential equations in two functions of a single independent variable over an interval. Homogeneous and non-homogeneous systems. Existence and uniqueness theorem (without proof). Set of solutions of a homogeneous system forms a vector space. Wronskian of any two solutions of a homogeneous system either vanishes throughout the interval or does not vanish anywhere in the interval. General solution of a homogeneous system. Description of general solution of a nonhomogeneous system in terms of one of its particular solutions and general solution of the corresponding homogeneous system. Every system corresponds to a linear differential equation of suitable order and vice versa.	[3L]
3.2	Solutions of a homogeneous system with constant coefficients. Obtaining a particular solution of a nonhomogeneous system using the method of variation of parameters. Nonlinear systems. Volterra's Prey-Predator equations.	[3L]
3.3	Transforms on the space of functions. Integral transforms. Definition of Laplace transform: Laplace transforms of standard functions such as constant function, monomials, exponential functions, sine and cosine functions, sine hyperbolic and cos hyperbolic functions. Examples of functions which do not have a Laplace transform.	[4L]

	General properties of Laplace transforms involving computation such as $$L[\alpha f(x)+\beta g(x)]=\alpha F(p)+\beta G(p), L[e^{\alpha x}f(x)]=F(p-\alpha),$$ $$L[f'(x)]=pF(p)-f(0), L[f''(x)]=p^2f(p)-pf(0)-f'(0)$$ $$L\left[\int_0^x f(t)dt=\frac{F(p)}{p}\right], L[-xf(x)]=F'(p), L[(-1)^n x^n f(x)]=F^{(n)}(p),$$ $$L\left[\frac{f(x)}{x}\right]=\int_p^\infty F(p)dp, L\left[\int_0^x f(x-t)g(t)dt\right]=F(p)G(p)$$	
3.4	Inverse Laplace transforms. (Formulae without proof) Applications of Laplace transform to differential equations of order 1 and 2. (Simple problem only.)	[2L]

References:

- G. F. Simmons; Differential equations with Applications and Historical Notes; McGraw Hill Education
- Joel L. Schiff; The Laplace Transform: Theory and Applications; Springer
- Norman W. McLachian; Laplace Transforms and their Applications to Differential Equations; Dover Publications

Additional Reference books:

- M.D. Raisinghania; Advanced Differential Equations; S. Chand Publications
- H. K. Dass; Higher Engineering Mathematics; S. Chand Publications
- Murray R. Spiegel; Laplace Transforms; Schaumn Series

Question Paper Template
S.Y. B. Sc. (Mathematics) SEMESTER IV
Core Course- I
COURSE TITLE: Ordinary differential equations
COURSE CODE: 22US4MTCC1ODE [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	2	10	3	10	-	5	30
II	2	5	3	10	5	5	30
III	2	5	3	10	10	-	30
Total marks per objective	6	20	9	30	15	10	90

% Weightage	6.7%	22.2%	10%	33.3%	16.7%	11.1 %	100

S.Y. B. Sc. (Mathematics) SEMESTER IV
Core Course- II
COURSE TITLE: Linear Algebra - II
COURSE CODE: 22US4MTCC2LAG [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to: 1: Determine the linear transformation and its matrix representation by its values on a basis. 2: Apply results proved to solve problems on orthogonal transformations and isometries. 3: Appreciate the first isomorphism theorem of real vector spaces.		
Module 1	Linear transformation and its matrix representation	[18L]
Learning Objectives: This module is intended to 1. Study linear transformation and matrix associated with it 2. Evaluate the rank of a matrix/ linear transformation 1. Prove results associated with linear transformation		
Learning Outcomes: After the successful completion of the module, the learner will be able to 1. Verify whether the given map is a linear transformation 2. Find kernel and image of a linear transformation 3. Prove results associated with a linear transformation such as rank-nullity theorem etc. 4. Find matrix associated for a given linear transformation w.r.t given ordered bases and vice-versa 5. Identify isomorphic vector spaces 6. Establish equivalence of rank of a matrix and a linear transformation associated with it 7. Apply the concept of rank to determine the consistency of a system of linear equations 8. Apply results proved to solve problems		
1.1	Definition and examples of Linear Transformation. Properties that follow consequently from definition.	[3L]
1.2	Determining a linear transformation by its values on a basis. Kernel and	[4L]

	Image of a Linear transformation, Rank-Nullity theorem, composite of a linear transformation.	
1.3	Non-singular linear transformation, Linear Isomorphism, related results.	[4L]
1.4	Representation of a linear transformation by a matrix w.r.t. given ordered bases, matrix of sum, scalar multiple, inverse and composite of linear transformation.	[3L]
1.5	Equivalence of rank of a matrix and a linear transformation associated with it. The solutions of non-homogeneous system of linear equations represented by AX=B	[4L]

References:

- S. Kumaresan -Linear algebra : a geometric approach, PHI Learning
- Serge Lang – Linear algebra, Springer.
- I.K.Rana – Linear algebra, math4all.

Additional Reference books:

- Schaum Series – Linear algebra.
- K Hoffman and R Kunze; Linear Algebra , Prentice-Hall INC.
- Gilbert Strang; Introduction to Linear Algebra Wellesley Publishers.

Module 2	Orthogonal Transformations and Isometries	[10L]

Learning Objectives:

This module is intended to

1. Study the concept of orthogonal transformations and isometries in finite dimensional inner product space
2. Classify all the orthogonal transformations in $\mathbb{R}^2$

Learning outcomes:

After the successful completion of the module, the learner will be able to

1. Establish equivalence of orthogonal transformations and isometries fixing origin on a finite dimensional inner product space
2. Express an isometry as a composition of an orthogonal transformation and a translation
3. Classify all the orthogonal transformations in $\mathbb{R}^2$ as a reflection or a rotation.

2.1	Orthogonal transformations definition and simple examples, isometry of a real finite dimensional inner product space. Translations and reflections with respect to a hyper plane	[4L]

2.2	Equivalence of orthogonal transformations and isometries fixing origin on a finite dimensional inner product space. Characterization of isometries as composite of orthogonal transformations and translation	[3L]
2.3	Orthogonal transformation of $\mathbb{R}^2$. Any orthogonal transformation in $\mathbb{R}^2$ is a reflection or a rotation.	[3L]

References:

- S. Kumaresan -Linear algebra : a geometric approach, PHI Learning
- Serge Lang – Linear algebra, Springer.
- I.K.Rana – Linear algebra, math4all.

Additional Reference books:

- Schaum Series – Linear algebra.
- K Hoffman and R Kunze; Linear Algebra, Prentice-Hall INC.
- Gilbert Strang; Introduction to Linear Algebra Wellesley Publishers.

Module 3	Quotient Spaces	[12L]

Learning Objectives:

This module is intended to

1. Understand concepts of cosets and quotient space
2. Prove results related to quotient space
3. Solve problems based on proved results

Learning outcomes:

After the successful completion of the module, the learner will be able to

1. Find the cosets for a given subspace of a finite dimensional vector space
2. Find basis and dimension of a quotient space V/W, when V is finite dimensional
3. Prove the results such as First Isomorphism theorem
4. Apply results proved to solve problems

3.1	Definition of Coset of a subspace in a real vector space and its examples	[2L]
3.2	The quotient space V/W. First Isomorphism theorem of real vector spaces (Fundamental theorem of homomorphism of vector spaces.)	[3L]
3.3	Dimension and basis of the quotient space V/W, when V is finite dimensional	[3L]

References:

- S. Kumaresan -Linear algebra: a geometric approach, PHI Learning
- Serge Lang – Linear algebra, Springer.
- I.K.Rana – Linear algebra, math4all.

Additional Reference books:

- Schaum Series – Linear algebra.
- K Hoffman and R Kunze; Linear Algebra, Prentice-Hall INC.
- Gilbert Strang; Introduction to Linear Algebra Wellesley Publishers.

Question Paper Template

S.Y. B. Sc. (Mathematics) SEMESTER IV

Core Course- II

COURSE TITLE: Linear Algebra - II

COURSE CODE: 22US4MTCC2LAG [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	8	10	9	9	4	45
II	2	5	5	10	5	-	27
III	3	5	5	5	-	-	18
Total marks per objective	10	18	20	24	14	4	90
% Weightage	11.11%	20.0%	22.22 %	26.66 %	15.55%	4.44 %	100

SYBSC (MATHEMATICS) SEMESTER IV
Core Course- III
COURSE TITLE: Numerical methods
COURSE CODE: 22US4MTCC3NUM [CREDITS - 02]

Course Learning Outcome
After the successful completion of the Course, the learner will be able to: 1: Generate approximate functions to approximate given data within the acceptable error limit 2: Fit polynomial curves to a set of data using techniques such as Fourier transforms, Gram-Schmidt orthogonalization process, Chebyshev polynomial etc 3: Solve problems of differentiation, integration and ordinary differential equations within the acceptable error limit

Module 1	Errors, solving an equation, System of equations and Interpolation	[12L]
Learning Objectives: This module is intended to 1. Study different numerical methods 2. Find approximate roots of a single equation and solution of a system of equations 3. Appreciate the rate of convergence of various methods 4. Study Interpolation methods		
Learning Outcomes: After the successful completion of the module, the learner will be able to 1. Articulate the trade-offs between easy computation and accuracy 2. Design an equation for a given situation 3. Find roots of an equation 4. Find solution of a system of equations 5. Interpolate values for a set of data		
1.1	Errors in Numerical calculations: Significant digits, Round off errors, Truncation errors, Absolute, relative and Percentage errors, General error formula, Error in a series approximation	[1L]
1.2	Solving algebraic and transcendental equation:	[5L]

	Bisection method, Regula-falsi, Newton - Raphson method, Ramanujan's method, Muller’s method.	
1.3	Solving system of equations: Linear System- LU decomposition: Doolittle's method, Gauss - Seidel's method Nonlinear system: Newton - Raphson's method	[3L]
1.4	Interpolation: Errors in polynomial Interpolation, Forward interpolation, central difference method, Lagrange’s method	[3L]

References:

- Steven C. Chapra and Raymond Canale; Numerical Methods for engineers; Fifth Edition; Tata McGraw hill education private ltd.
- S.S.Sastry, Introductory methods of numerical analysis, Prentice-Hall India, 1977.
- K.E. Atkinson, An introduction to numerical analysis, John Wiley and sons, 1978.
- Jain, Iyengar, Numerical methods for scientific and engineering problems, New Age International, 2007.
- H.M.Antia , Numerical Analysis for scientists and engineers, TMH 1991.

Module 2	Least Square and Fourier transforms	[12L]

Learning Objectives:

This module is intended to

1. learn different numerical methods to approximate any curve or set of points by polynomial and trigonometric function

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Approximate any curve or set of points by polynomial and trigonometric function with desired accuracy in any bounded interval

2.1	Curve fitting by a polynomial curve fitting by sum of exponential, nonlinear weighted least square approximation	[3L]
2.2	Orthogonal polynomials, Gram-Schmidt orthogonalisation process, Chebyshev polynomial	[4L]
2.3	Fourier approximation, Fourier transforms, Discrete Fourier transforms (DFT), Fast Fourier transforms (FFT)	[5L]

References:

- Steven C. Chapra and Raymond Canale; Numerical Methods for engineers; Fifth Edition; Tata McGraw hill education private ltd.
- S.S.Sastry, Introductory methods of numerical analysis, Prentice-Hall India, 1977.
- K.E. Atkinson, An introduction to numerical analysis, John Wiley and sons, 1978.
- Jain, Iyengar, Numerical methods for scientific and engineering problems, New Age International, 2007.
- H.M.Antia , Numerical Analysis for scientists and engineers, TMH 1991.

Module 3	Numerical differentiation, integration and solving ordinary differential equation	[12L]

Learning Objectives:

The module is intended to

1. Study different numerical methods for solving differentiation, integration and ordinary differential equations.
2. Evaluating Errors from different methods

Learning Outcomes:

After the successful completion of the module, the learner will be able to

1. Solve derivatives, integration and ordinary differential equations using different numerical method at a point
2. Prove results.
3. Evaluate errors from all the methods

3.1	Numerical differentiation: Errors in Numerical differentiation, cubic spline method, forward difference method, Lagrange's method, central difference 4th order method. Approximate Maximum and minimum value of a tabulated function within the given range.	[4L]
3.2	Numerical Integration: Trapezoidal method, Simpson’s rule. Errors from these methods	[3L]
3.3	Ordinary differential equations: Taylor's method, Euler’s method, Euler’s modified method, Runge Kutta's 4th order method Multi step Predictor Corrector method: Adams - Bashforth- Moulton method, Milne-Simpson's method	[5L]

References:

- Steven C. Chapra and Raymond Canale; Numerical Methods for engineers; Fifth Edition; Tata McGraw hill education private ltd.
- S.S.Sastry, Introductory methods of numerical analysis, Prentice-Hall India, 1977.
- K.E. Atkinson, An introduction to numerical analysis, John Wiley and sons, 1978.
- Jain, Iyengar, Numerical methods for scientific and engineering problems, New Age International, 2007.
- H.M.Antia , Numerical Analysis for scientists and engineers, TMH 1991.

Question Paper Template
SYBSC (MATHEMATICS) SEMESTER IV
Core Course- III
COURSE TITLE: Numerical methods
COURSE CODE: 22US4MTCC3NUM [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	3	7	10	5	-	5	30
II	3	7	5	5	5	5	30
III	3	7	5	10	5	-	30
Total marks per objective	9	21	20	20	10	10	90
% Weightage	10%	23.33%	22.22 %	22.22 %	11.11%	11.12 %	100

S. Y. B. Sc. (Mathematics)
SEMESTER IV - Practical
COURSE CODE: 22USCCMTP [Credit- 02]

Learning Objectives:

The Practical is intended to

1. Solve problems based on the concepts learnt
2. Apply the concepts in various situation

Learning Outcomes:

After the successful completion of the practical, the learner will be able to

1. Solve problems
2. Apply the results proved
3. Generate examples and counterexamples

Module I	Real Analysis-II
	1.1 Identification of degree and order of a differential equation and problems based on variables separation, homogeneous differential equations and exact differential equation.
	1.2 Problems based on linear differential equation of order 1 and Bernoulli's differential equation. Applications such as obtaining orthogonal family of curves, exponential growth and decay, R-C circuits and L-R circuits.
	1.3 Solving a second order homogeneous linear differential equation with constant coefficients. Using a known solution to find another linearly independent solution. Testing linear dependence and independence of two solutions using Wronskian.
	1.4 Solving a nonhomogeneous differential equation by finding a particular integral using the method of undetermined coefficients and method of variation of parameters. Applications based on freely falling bodies and on Hook's Law.
	1.5 Problems based on systems of first order differential equations

	1.6 Problems on finding Laplace transform and Inverse Laplace transform. Use of Laplace transform in solving simple
Module 2	Linear Algebra-II
1.1 Problems on finding linear transformation, rank nullity theorem.	
1.2 Problems on matrix associated with a linear transformation.	
1.3 Problems on solutions of non-homogeneous system of linear equations	
1.4 Problems on orthogonal transformations, reflections, translations with respect to a hyper plane.	
1.5 Problems on isometries.	
1.6 Problems on Quotient space.	
Module 3	Numerical Methods
3.1 Solving equations and system of equations and corresponding error analysis	
3.2 Interpolations and corresponding error analysis	
3.3 Polynomial curve fitting	
3.4 Fourier approximation	
3.5 Differentiation and Integration	
3.6 Numerical solution of Ordinary Differential Equations	

Assessment Methods

Evaluation Pattern: Theory

- Assessments are divided into two parts: Continuous Internal Assessment (CIA) & Semester End Examination.
- The Semester End Examination shall be conducted by the college at the end of each semester.
- Semester End Examination (external) (60 M)- Duration:
  2 hours Paper Pattern

Guidelines about conduct of Projects/Case Study:

Projects/ Case Study/ Book Review:

Conduct and Evaluation: A learner can submit a project/ Case Study/ do a Book review. The project should be 10-page typed pages in an A4 size paper with font size of 12. The topic of project should be selected in consultation of the teacher. Maximum marks allotted for this is 20 and the remaining 20 marks are from tests and other activities.

The topic can be of expository / historical survey / interdisciplinary nature and the material covered in the project / case study should go beyond the scope of the syllabus. The learner must clearly mention the sources (Book / on-line) used for the project/ case study. The use of Mathematical software is encouraged. The project should be done under the supervision of a faculty in a college/ university or an institution.

The following Marking scheme is suggested for evaluation of projects / case study:

30% marks for exposition
20% marks for literature
20% marks for Scope
10% marks for originality
20% marks for presentation.

Continuous evaluation:
Internal evaluation (40%):

1. There will be 40 marks continuous evaluation.
2. A learner can be assigned projects/book review, this will be evaluated out of 20 marks.

3. The project / book review will be under the guidance of the mentor allotted to the learners by the head of the department.
4. There will be regular tests which can be of the form quiz/ descriptive test/ objective test/ group discussion presentation etc.
5. Each test will be marked out of 20 marks.
6. The total score obtained in all of the above will finally be averaged to 40 marks.
7. A learner should secure at least 40% marks to be eligible to get a passing grade (The learner needs to secure minimum of 16 marks out of 40 to pass the internal for each theory course).
8. A learner who has failed to secure a passing grade /absent for any reason in the internal evaluation will have to give test out of 40 marks, consisting of Questions based on the entire syllabus.
9. All tests will be averaged to 25 marks, other activities averaged to 15 marks.

<u>Semester end Examination (60%):</u>

At the end of the semester there will be a semester end exam carrying a maximum of 60 marks.

1. There will be 4 Questions one from each Module. Each question will carry 15 marks unless otherwise stated in the syllabus (with option, maximum of 25 marks). The question paper will cover the whole syllabus in such a way that a learner will need to have understood each topic well to have secured 80% and above and an average learner can at least secure a passing grade.
2. A learner should secure at least 40% marks to be eligible to get a passing grade (The learner needs to secure minimum of 24 marks out of 60 to pass the semester end examination for each theory course).

<u>Practical examination</u>

1. Practical Examination out of 100 marks will be conducted based on the theory courses.
2. 40% evaluation will be based on continuous evaluation and balance 60% will be Semester end examination.
3. Certified Journal will be part of internal evaluation.
4. Internal evaluation will be based on experiential learning such as preparing Mathematical model/ Games/quizzes, Applying Concepts learnt in other areas of mathematics or other Sciences, Presentations.
5. Contribution during Cooperative/Participative learning will be evaluated during regular practical. No prior intimation will be given.
6. Semester end examination of the Practical examination will be descriptive and will be based on the entire syllabus of both theory courses.

Distribution of marks for practical examination out of 100. (Corresponding modification for exam conducted out of 150 marks)

Mathematics

	Course 1	Course 2	Total
	Internal Continuous Assessment		
Objective questions	6	6	12
Journal	5	5	10
Viva	5	5	10
Modelling	4	4	8
Total	20	20	40
	Semester end descriptive problem solving		
Comprehension type	6	6	12
Application type	8	8	16
Analysis type	8	8	16
Evaluation/Creating type	8	8	16
Total	30	30	60

Examination for unsuccessful learners (Termed as ATKT examination)

- Internal examination will be a test conducted out of 40 marks based on the entire syllabus. It will be written test/ online test as per the situation. Details of the pattern etc will be uploaded in the noticeboard section of our website kjssc.somaiya.edu
- Semester Exam will have the same paper pattern as the regular exam. (Subject to change.)
- Internal Component of the Practical Examination (40%) will be objective based examination. This will include journal marks (only Certified Journal will be eligible for marks)
- Notice regarding syllabus will be uploaded in the noticeboard section in our website.