**MINOR BASKET I – APPLIED MATHEMATICS**

| Sl. No. | Course Code | Course Name | Semester of Study |
|---|---|---|---|
| 1 | 23MAL2MA | Advanced Linear Algebra | S3 |
| 2 | 23MAL2MB | Mathematical Optimization | S4 |
| 3 | 23MAL3MA | Random Process and Queuing Theory | S5 |
| 4 | 23MAL3MB | Algebra and Number Theory | S6 |
| 5 | 23MAL4MA | Advanced Numerical Computations | S7 |

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|---|
| 23MAL2MA | ADVANCED LINEAR ALGEBRA | MINOR | 3 | 0 | 0 | 0 | 3 | 2023 |

## i) COURSE OVERVIEW

This course introduces the concept of a vector space which is a unifying abstract framework for studying linear operations involving diverse mathematical objects such as n- tuples, polynomials, matrices and functions. Students learn to operate within a vector and between vector spaces using the concepts of basis and linear transformations. The concept of inner product enables them to do approximations and orthogonal projects and with them solve various mathematical problems more efficiently.

## ii) COURSE OUTCOMES

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Identify many of familiar systems as vector spaces and operate with them using vector space tools such as basis and dimension | Apply |
| CO2 | Identify linear transformations and manipulate them using their matrix representations. | Apply |
| CO3 | Apply the concept of real and complex inner product spaces in constructing approximations and orthogonal projections | Apply |
| CO4 | Compute eigenvalues and eigenvectors and use them to diagonalize matrices and simplify representation of linear transformations | Apply |
| CO5 | Apply the tools of vector spaces to decompose complex matrices into simpler components, find least square approximations, solution of systems of differential equations etc. | Apply |

## iii) SYLLABUS

Vector Spaces, Subspaces -Definition and Examples. Linear independence of vectors, Linear span, Bases and dimension, Co-ordinate representation of vectors. Row space, Column space and null space of a matrix

Linear transformations between vector spaces, matrix representation of linear transformation, change of basis, Properties of linear transformations, Range space and Kernel of Linear transformation, Inverse transformations, Rank Nullity theorem, isomorphism.

Inner Product: Real and complex inner product spaces, properties of inner product, length and distance, Cauchy-Schwarz inequality, Orthogonality, Orthonormal basis, Gram Schmidt orthogonalization process. Orthogonal projection. Orthogonal subspaces, orthogonal compliment, and direct sum representation.

Eigen values, eigenvectors and eigen spaces of linear transformation and matrices, Properties of eigenvalues and eigenvectors, Diagonalization of matrices, orthogonal diagonalization real symmetric matrices, representation of linear transformation by diagonal matrix, Power method for finding dominant eigenvalue

LU-decomposition of matrices, QR-decomposition, Singular value decomposition, Least squares solution of inconsistent linear systems, curve-fitting by least square method, solution of linear systems of differential equations by diagonalization

**iv) a) TEXTBOOKS**

1. Richard Bronson, Gabriel B. Costa, Linear Algebra-an introduction, 2nd edition, Academic press, 2007
2. Howard Anton, Chris Rorres, Elementary linear algebra: Applications versio, 9th edition, Wiley

**b) REFERENCES**

1. Gilbert Strang, Linear Algebra and It's Applications, 4th edition, Cengage Learning, 2006
2. Seymour Lipschutz, Marc Lipson, Schaum's outline of linear algebra, 3rd Ed., Mc Graw Hill Edn.2017
3. David C Lay, Linear algebra and its applications,3rd edition, Pearson
4. Stephen Boyd, Lieven Vandenberghe, Introduction to Applied Linear Algebra: Vectors, Matrices,and Least Squares, Cambridge University Press, 2018
5. W. Keith Nicholson, Linear Algebra with applications, 4th edition, McGraw-Hill, 2002

**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Vector spaces<br>Defining of vector spaces, example, Subspaces, Linear dependence, Basis, dimension, Row space, column space, rank of a matrix, Co ordinate representation | 9 |
| II | Linear Mapping<br>General linear transformation, Matrix of transformation Kernel and range of a linear mapping Properties of linear transformations<br>Rank Nullity theorem, Change of basis, Isomorphism | 9 |
| III | Inner product spaces<br>Inner Product: Real and complex inner product spaces, Properties of inner product, length and distance Triangular inequality, Cauchy-Schwarz inequality Orthogonality, Orthogonal complement, Orthonormal bases Gram Schmidt orthogonalization process, orthogonal projection Direct sum representation | 9 |
| IV | Eigen values and Eigen vectors Eigen values and Eigen vectors of a linear transformation and matrix, Properties of Eigen values and Eigen vectors | 9 |

| | | |
|---|---|---|
| | Diagonalization., orthogonal diagonalization Power method, Diagonalizable linear transformation | |
| **V** | Applications LU decomposition, QR Decomposition Singular value decomposition, Least square solution, Curve fitting, Solving systems of differential equations. | **9** |
| | **Total** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 40
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours

| Course Code | Course Name | Category | L | T | P | J | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|---|
| 23MAL2MB | MATHEMATICAL OPTIMIZATION | MINOR | 3 | 0 | 0 | 0 | 3 | 2023 |

**i) COURSE OVERVIEW**

This course introduces basic theory and methods of optimization which have applications in all branches of engineering. Linear programming problems and various methods and algorithms for solving them are covered. Also introduced in this course are transportation and assignment problems and methods of solving them using the theory of linear optimization. Network analysis is introduced which has applications in planning, scheduling, controlling, monitoring and coordinating large or complex projects involving many activities. The course also includes a selection of techniques for non-linear optimization.

**ii) COURSE OUTCOMES**

After the completion of the course, the student will be able to:

| | | |
|---|---|---|
| CO1 | Solve linear programming problems using graphical or simplex method. | Apply |
| CO2 | Solve linear programming problems using duality theorems. | Apply |
| CO3 | Solve transportation and assignment problems using appropriate optimization techniques. | Apply |
| CO4 | Solve sequencing and scheduling problems and gain proficiency in the management of complex projects involving numerous activities using appropriate techniques. | Apply |
| CO5 | Solve non-linear optimization problems by identifying and classifying them using appropriate methods. | Apply |

**iii) SYLLABUS**

Linear Programming Problem – Graphical solution, Simplex Method, Big-M method.

Two-phase method, Degeneracy and unbounded solutions of LPP, Duality in LPP, Dual Simplex Method.

Transportation Problem, Finding basic feasible solutions–MODI method. Assignment problem, Hungarian method for optimal solution, Solution of unbalanced problem. Travelling salesman problem

Introduction, Problem of Sequencing, Scheduling Project Management-Critical path method (CPM), Project evaluation and review technique (PERT), Optimum scheduling by CPM, Linear programming model for CPM and PERT. Nonlinear programming problems-graphical illustration. Constrained and unconstrained optimization problems- gradient search. The Karush –Kuhn Tucker conditions- Quadratic programming.

**iv) a) TEXTBOOKS**


1. Frederick S Hillier, Gerald J. Lieberman, Introduction to Operations Research, Seventh Edition, McGraw-Hill Higher Education, 1967.
2. Kanti Swarup, P. K. Gupta, Man Mohan, Operations Research, Sultan Chand Sons, New Delhi, 2008.


**b) REFERENCES**


1. Singiresu S Rao, Engineering Optimization: Theory and Practice, New Age, International Publishers, 1996
2. H A Taha, Operations research: An introduction, Macmillon Publishing company,1976
3. B. S. Goel, S. K. Mittal, Operations research, Pragati Prakashan, 1980
4. S.D Sharma, "Operation Research", Kedar Nath and RamNath - Meerut, 2008.
5. Grewal B.S., "Higher Engineering Mathematics"- 40th Edition, Khanna Publishers, Delhi 2018.


**v) COURSE PLAN**

| Module | Contents | No. of hours |
|---|---|---|
| I | Linear Programming Problem – Mathematical Formulation of LPP-Basic feasible solutions, Graphical solution of LPP- Canonical form of LPP, Standard form of LPP, slack variables and Surplus variables, Artificial variables in LPP-Simplex Method Big-M method. | 9 |
| II | Two-phase method -Degeneracy and unbounded solutions of LPP Duality of LPP -Solution of LPP using principle of duality. Dual Simplex Method. | 9 |
| III | Balanced transportation problem -Finding basic feasible solutions – Northwest corner rule, least cost Method-Vogel's approximation method. MODI method, unbalanced Transportation Problem Assignment problem, Formulation of assignment problem Hungarian method for optimal solution, Solution of unbalanced Problem. | 9 |
| IV | Introduction, Problem of Sequencing, the problem of n jobs and two machines -problem of m jobs and m machines<br>Scheduling Project Management-Critical path method (CPM)<br>Project evaluation and review technique (PERT), Optimum scheduling by CPM, Linear programming model for CPM<br>and PERT. | 9 |

| | | |
|---|---|---|
| **V** | Nonlinear programming problems- graphical illustration. Constrained and unconstrained optimization problems- gradient search -steepest descent method, conjugate gradient method, Powell's method. The Karush –Kuhn Tucker conditions- Quadratic programming. | **9** |
| | **Total** | **45** |

**vi) ASSESSMENT PATTERN**

Continuous Assessment: End Semester Examination – 40 : 60

| Continuous Assessment | | |
|---|---|---|
| Attendance | : | 5 marks |
| Assignments | : | 15 marks |
| Assessment through Tests | : | 20 marks |
| **Total Continuous Assessment** | : | **40 marks** |
| **End Semester Examination** | : | **60 marks** |
| **TOTAL** | : | **100 marks** |

**vii) CONTINUOUS ASSESSMENT TEST**

- No. of tests: 02
- Maximum Marks: 40
- Test Duration: 1 ½ hours
- Topics: 2 ½ modules

**viii) END SEMESTER EXAMINATION**

- Maximum Marks: 60
- Exam Duration: 3 hours