**University of Management and Technology**

**Course Outline**

Course code MTH736 Course titleOptimization theory with Applications

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| Program | MS/PhD |
| Credit Hours | 03 |
| Duration | 01 Semester |
| Prerequisites | Basic acquiring general knowledge in and basic analysis, linear algebra, will enable the students to successfully apply it when needed in other courses. |
| Resource Person | Dr. Naeem Saleem |
| Counseling Timing  (Room# ) | 3S-39 |
| Contact | [naeem.saleem@umt.edu.pk](mailto:naeem.saleem@umt.edu.pk)  03214262145 |

**Chairman/Director signature………………………………….**

**Dean’s signature…………………………… Date………………………………………….**

**Learning Objective:**

This course has been designed for graduate students of computer sciences, economics, mathematics and applied mathematics.

Optimization is central to any problem involving decision making, whether in engineering or in economics. The task of decision making entails choosing between various alternatives. This choice is governed by our desire to make the "best" decision. The measure of goodness of the alternatives is described by an objective

function or performance index. Optimization theory and methods deal with selecting the best alternative in the sense of the given objective function.

The first part contains a review of some basic definitions, notations, and relations from linear algebra, geometry, and calculus that we use frequently throughout the book. In Part II we consider unconstrained optimization problems.

Parts III and IV are devoted to constrained optimization. Part III deals with linear programming

problems, which form an important class of constrained optimization problems. Part III by discussing some non-simplex algorithms for solving linear programs: Khachiyan's method, the affine scaling method.

Moreover, some applications in computer sciences, game theory, economics, behavioral sciences and biology will be covered as well.

**Learning Methodology:**

After successfully completing the course, students should be

1. comfortable with several concepts involving basic mathematics,
2. able to understand several tools related to optimization therory
3. able to apply the concepts in problems related to computer sciences, economics, and behavioral sciences.

**Grade Evaluation Criteria**

Following is the criteria for the distribution of marks to evaluate final grade in a semester.

**Marks Evaluation Marks in percentage**

Quizzes 10

Assignments 10

Mid Term 25

Attendance & Class Participation 00

Term Project 10

Presentations 05

Final exam 40

Total

**Recommended Text Books:**

1. A Course on Optimization and Best Approximation **by Holmes**, R. B 1972.
2. A survey, [NONLINEAR APPROXIMATION](http://www.cs.wisc.edu/~deboor/887_98/nonlinear.ps) by Ron DeVore, that has appeared in Acta Numerica; 7; 1998.
3. An Introduction to optimization, 2nd Edition, By, E.K.P. Chong and S.H.Zak, Willeys, 2001

**Reference Books:**

1. [History of Approximation Theory](http://www.math.technion.ac.il/hat/) and its [mirror](http://www.cs.wisc.edu/~deboor/HAT/): [A Short Course on Approximation Theory](http://personal.bgsu.edu/~carother/Approx.html) by Neal Carothers [Constructive Approximation](http://www.fi.uib.no/~antonych/Approx.html)
2. A.L.Brown and A. Page , Elements of functional analysis. Van Nostrand Reinhold, 1970
3. M.C. Joshi And R.K. Bose: Some Topics in Nonlinear Functional Analysis, John Wiley and Sons, 1985

**Calendar of Course contents to be covered during semester**

**Course code……………………………...... Course title** Optimization theory and its applications

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| --- | --- | --- |
| **Week** | **Course Contents** | **Reference Chapter(s)** |
| 1 | Real Vector Spaces  Rank of a Matrix  Linear Equations  Inner Products and Norms |  |
| 2 | Linear Transformations  Eigenvalues and Eigenvectors  Orthogonal Projections  Quadratic Forms  Matrix Norms |  |
| 3 | Sequences and Limits, Differentiability ,The Derivative Matrix, Differentiation Rules, Level Sets and Gradients |  |
| 4 | Conditions for Local Minimizer,  Golden Section Search,  Fibonacci Search  Newton's Method  Secant Method  Remarks on Line Search Methods |  |
| 5 | The Method of Steepest Descent  Analysis of Gradient Methods  Convergence  Convergence Rate |  |
| 6 | Analysis of Newton's Method  Levenberg-Marquardt Modification  Newton's Method for Nonlinear Least-Squares |  |
| 7 | Mid Term  **Approximation of Functions:** Approximating the Inverse Hessian  The Rank One Correction Formula  The DFP Algorithm  The BFG Algorithm |  |
| 8 | Least-Squares Analysis  Recursive Least-Squares Algorithm  Solution to *Ax = b* Minimizing ||*x*||  Kaczmarz's Algorithm  Solving *Ax = b* in General |  |
| 9 | Single-Neuron Training  Backpropagation Algorithm |  |

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| --- | --- | --- |
| 10 | Chromosomes and Representation Schemes  Selection and Evolution  Analysis of Genetic Algorithms  Real-Number Genetic Algorithms, |  |
| 11 | Linear Programming, Two-Dimensional Linear Programs, Convex Polyhedra and Linear Programming, Basic Solutions, A Geometric View of Linear Programs |  |
| 12 | Solving Linear Equations Using Row Operations, The Canonical Augmented Matrix, Updating the Augmented Matrix, The Simplex Algorithm, The Two-Phase Simplex Method, The Revised Simplex Method Project |  |
| 13 | Presentations  Dual Linear Programs  Khachiyan's Method  Affine Scaling Method  Two-Phase Method  From General Form to Karmarkar's Canonical  Form , The Algorithm |  |
| 14 | Project  Presentations  Karush-Kuhn-Tucker Condition  Second-Order Conditions  Convex Optimization Problems |  |
| 15 | Final Term |  |