NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF SCIENCES
MATHEMATICS PROGRAM

CM454 – NON-LINEAR PROGRAMMING

I. GENERAL INFORMATION

CODE	: CM454 Non-Linear Programming
SEMESTER	: 8
CREDITS	: 6
HOURS PER WEEK	: 8 (Theory – Practice – Seminar)
PREREQUISITES	: CM355 Linear Programming CM413 Functional Analysis I
CONDITION	: Mandatory

II. COURSE DESCRIPTION

The subject has a practical theoretical nature, it will be developed by theoretical classes. Students must attend both theoretical and practical classes. Its purpose is to provide students with skills in the area of mathematical programming through the results of optimization and operational research. Among the topics to be developed we have optimization, convex analysis, separation, basic results of the subdifferential theory, optimality conditions, Lagrangian duality, non-linear programming with and without restrictions, introduction to multiobjective programming.

III. COURSE OUTCOME

Develops skills in the application of theoretical concepts for practical problems. The students can formulate mathematical algorithms to find stationary points, as well as optimal solutions to non-linear optimization programs. They can formulate and solve modeled problems using non-linear programs. Apply the optimality conditions; can formulate dual problems and solve them by the cutting method. Understand and apply different algorithmic methods for problems without restrictions.

IV. LEARNING UNITS

1. **First unit. Convex Analysis Elements. 16 hours**

   Convex Functions / Special Convex Functions / Convex Cones / Base and Generator Sets of a Polar Cone / Cones, conjugate / Frarkas' lemma / Alternatives Theorem / Primal - Dual Linear Relationship with Farkas' Lemma.

2. **Second Unit. Separation. 16 hours**

Related sets / Hyperplanes / Separation of point and sets / Separation of sets. Geometric interpretation / Separation of cone and set / Projection on convex sets / Unicity of the projection / Linear functional / Minkowski's functional. Separation by functional.

3. **Third unit. Generalized Convexity. 8 hours**

   Quasi-Convex Functions / Properties / Pseudo-convexity / Subdifferential / Subgradient. Directional derivative and its relation to the subgradient.

4. **Fourth Unit. Non-Linear Programming 16 hours**

   Introduction to multiobjective programming / Formulation of the problem / Partial order and cones / Total order and linear partial order / Pointed cone / Core of a set / Algebraic concepts: algebraic boundary and algebraically closed and bounded set / Algebraic closure / Minimal and maximal elements of a set / Vector space and its algebraic dual, algebraic dual cone / Convex application and ordering cone C.

5. **Fifth Unit. Programming without Restrictions. 8 hours**

   Formulation / Weierstras' Theorem / Level curves and sets and their application / Optimality conditions.

6. **Sixth Unit. Solution Methods for Programs. Without Restrictions. 12 hours**

   Linear search / Newton method. Gradient / Optimal Gradient / Quadratic forms / Conjugated directions regarding the symmetric matrix.

7. **Seventh Unit. Programming with Restrictions. 8 hours**

   Formulation of the general problem / The Lagrangian / Karush-Khun-Tucker Conditions / Penalty method / Duality. Geometric interpretation / Solution of the dual problem / Cutting plane methods / Examples.

V. BIBLIOGRAPHY

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- Izmailov, Alexey, Otimização-volume 1. MPA 2014
- Bazaraa, Mokhtar, Nonlinear Programming Theory and Algorithms. Third Edition 2006
- Bertsekas, Dimitri P., Nonlinear Programming. Amazon 1999
- Kiyotaka Shimizu, Y. Ishizuka and J. Bard " Nondifferentiable and Two - level Mathematical Programming" 2012
- Matthias Ehrgott, Multicriteria Optimization, Springer 2005.

- Jonathan F. Bard, Practical Bilevel Optimization, Algoriithms and Applications . Kluwer Academic Publisher 1999.

- Frank H. Clarbe, Optimization and Nonsmooth Analysis SIAM, JOHN WILEY & SONS, N.Y.1983.

- Olví L. Mangasarian, Nonlinear Programming. Mc Graw-Hill Book Company, 1969