NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF GEOLOGICAL, MINING AND METALLURGICAL ENGINEERING
METALLURGICAL ENGINEERING PROGRAM

PA713 – OPERATIONS RESEARCH

I. GENERAL INFORMATION

CODE	**:**	PA713 Operations Research
SEMESTER	**:**	8-10
CREDITS	**:**	3
HOURS PER WEEK	**:**	4 (Theory – Practice)
PREREQUISITES	**:**	ME421 Minerals and Materials Processing II
CONDITION	**:**	Elective

II. COURSE DESCRIPTION

This course trains students in the formulation and construction of linear optimization models. It deals with: enterprise, systems, mathematical models, solution to linear programming problems, solution methods for mathematical models of linear programming problems, duality and sensibility, special cases of linear programming, transport model and resources assignment. Problems about optimization for the improvement of mining operations and systems are solved. Specialized software is used.

III. COURSE OUTCOMES

At the end of this course students will be able to:

1. Optimize resources of organizations through mathematical models formulation and solution.
2. Analyze and assess the usefulness and costs impact through sensibility analysis of mathematical models.
3. Operate software for the solution and interpretation of results of production runs made for the optimization of modeled resources.

IV. LEARNING UNITS

1. THE ENTERPRISE, SYSTEMS, MATHEMATICAL MODELS AND SOLUTION TO LINEAR PROGRAMMING PROBLEMS / 16 HOURS

Introduction to the course. Introduction to operations research, operations research methodology, applications of mathematical programming models. System and mathematical models approach. Linear programming and its principles, formulation of mathematical models, problem data, identification of decision variables, identification of objective function or identification of restrictions. LPP (Linear Programming Problem) general format. Concepts of convexity: linear function, convex combination, convex set, space of possible solutions and extreme point. Fundamental theorems of linear programming. Solution graphic method for a 2-variable LPP. Section models. Standard form of an LPP.

2. SOLUTION METHODS FOR MATHEMATICAL MODEL OF LINEAR PROGRAMMING / 12 HOURS

Simplex methods and related theorems. Simplex algorithms and properties of the simplex board.

2-phase simplex method. Penalty method. Special cases in the solution of LPPs. Non-possible solutions, dimensioned, non-dimensioned, multiples and degenerated. Restrictions of inferior dimensions, Break-even point.

3. DUALITY AND SENSIBILITY ANALYSIS / 16 HOURS
Duality in linear programming, dual construction, determination of the dual optimal solution, complementary slackness theorem, economical interpretation of the dual problem. Dual simplex method, comparison between simplex and dual simplex. Sensibility analysis, sensibility level for variables in objective function, sensibility level for resources. Parametric analysis in linear programming, cost vector variations, resources availability variations, addition of a new variable, addition of a new restriction.

4. SPECIAL CASES OF LINEAR PROGRAMMING, TRANSPORT MODEL AND RESOURCES ASSIGNMENT MODEL / 12 HOURS
Applications of linear programming, Linear programming variations, special cases f linear programming. Transport model: North-west corner method, minimal cost method, Voguel's method. Transport model: empty cells method, MODI method (Modified Distribution Method), transshipment model, Resource assignment model. Hungarian method.

V. LABORATORIES AND PRACTICAL EXPERIENCES

Lab 1: System approach and mathematical models.
Lab 2: Formulation of Linear Programming Mathematical Models (LPMM).
Lab 3: Solution to LPMMs. Graphic method with use of software.
Lab 4: Solution to LPMMs. Simplex method with use of software.
Lab 5: Solution to LPMMs. Simplex method: penalty and double phase with use of software.
Lab 6: Solution to LPMMs. Duality and sensibility analysis with use of software.
Lab 7: Solution to Transport Mathematical Models with use of software.
Lab 8: Solution to Resource Assignment Mathematical Models with use of software.

VI. METHODOLOGY

This course is carried out in theory, practical and lab sessions. In theory sessions, the instructor introduces concepts, theorems and applications. In practical sessions, different problems are solved and their solutions are analyzed. In lab sessions, TORA, Excel, GLP, Winqsb, Lindo and Lingo software programs are used to solve problems and analyze their solutions. At the end of the course, students must hand over and expose a paper or integrating project. In all sessions, students' active participation is encouraged.

VII. EVALUATION FORMULA

The final grade PF is calculated as follows:

PF = (PL + 2EP + 2EF)/5

EP: Mid-Term Exam EF: Final Exam
PL: Lab average

VIII. BIBLIOGRAPHY

1. **H. TAHA, HAMDY**
   Introduction to Operations Research I (Spanish)
   McGraw Hill Editorial (2001)

2. **HILLIER AND LIEBERMAN**
   Introduction to Operations Research I (Spanish)
   McGraw Hill Editorial (2003)

IX. COURSE CONTRIBUTIONS TO STUDENT OUTCOMES ATTAINMENT

Course contributions to Student Outcomes are shown in the following table:

Level 1: Know
Level 2: Comprehend, calculate
Level 3: Model, apply, solve
Level 4: Apply at advanced level, design. Achievement of Student Outcome

Outcome	Contribution
1. Engineering Design Design and integrate metallurgical systems and components satisfying requirements and needs as well as given technical, economic, social and legal constraints and limitations.	
2. Problem solving Identify, formulate and solve engineering problems properly using the methods, techniques and tools of metallurgical engineering.	4
3. Sciences Application Apply the knowledge and skills of mathematics, sciences and engineering to solve metallurgical engineering problems.	4
4. Experimentation and Testing Conceive and conduct experiments and tests, analyze data and interpret results.	3
5. Modern Engineering Practice Use and apply techniques, methods and tools of modern engineering necessary for the practice of metallurgical engineering.	4
6. Engineering Impact Understand the impact of metallurgical engineering solutions on people and society in local and global contexts.	3
7. Project Management Determine the budgets, schedules and feasibility of engineering projects, and participate in its management for the attainment of goals.	3
8. Environmental Appraisal Take into account the importance of preserving and improving the environment in the development of their personal and professional activities.	3
9. Lifelong Learning Recognize the need to keep their knowledge and skills up-to-date according to advances of metallurgical engineering and engage in lifelong learning.	3
10. Contemporary Issues Know and analyze relevant contemporary issues in local, national and global contexts.	3
11. Ethics and Professional Responsibility Evaluate their decisions and actions from a moral perspective and assume responsibility for the executed projects.	
12. Communication Communicate clearly and effectively in oral, written and graphical formats, interacting with different types of audiences.	3
13. Teamworking Appraise the importance of teamworking and participate actively and effectively in multidisciplinary teams.	