NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF CIVIL ENGINEERING

CIVIL ENGINEERING PROGRAM

NUMERICAL METHODS

I. GENERAL INFORMATION

CODE	**:**	MA195
SEMESTER	**:**	4
CREDITS	**:**	3
HOURS PER WEEK	**:**	5 (Theory – Practice - Laboratories)
PREREQUISITES	**:**	COMPUTER PROGRAMMING
CONDITION	**:**	Compulsory
DEPARTAMENT	**:**	Basic Sciences
INSTRUCTOR	**:**	Leonardo Flores González, Cristina Navarro Flores, Ericka Valderrama Soto
INSTRUCTOR E-MAIL	**:**	leo_flo_gon_2005@yahoo.com, crinavarrof@hotmail.com, evalderramas02@yahoo.com

II. COURSE DESCRIPTION

The course provides theoretical concepts and applications on numerical simulation that analyze, recognize and develop numerical techniques relating to engineering. The study of sequences makes understanding the convergence and limitations of each method. Linear systems offer the possibility to the future engineers to address problems with large number of variables. The eigenvalues and eigenvectors are used in vibration problems and provide the support in numerical engineering problems related to earthquake engineering. Interpolation methods help to represent a variety of functions related to engineering problems which are develop on the latest topics of the course.

III. COURSE OUTCOMES

1. Properly used of concepts related to sequences and convergence of numerical methods.
2. Apply various methods of linear systems to support the solving of numerical models for engineering.
3. Meet concepts of eigenvalues and eigenvectors applied on vibration problems selecting the most appropriate method.
4. Understand the concept of interpolation, which is used to represent various functions and applied in several units of the course.
5. Use numerical integration to solve various problems related to civil engineering concepts. Apply concepts of numerical integration to solve numerical models which represent differential equations.
6. Encourage the interest in solving, application and representation of engineering problems by numerical models.

IV. LEARNING UNITS

1. EQUATIONS IN A VARIABLE / 9 HOURS

Introduction to the error theory. Sequences. Bisection method. The fixed-point iteration. Newton method. Secant method.

2. LINEAR SYSTEMS / 6 HOURS

Fundamentals: elementary matrix, Euclidean and infinitive matrix norms. A = LU and PA = LU Factorizations. Cholesky factorization. Solving linear systems by factoring presented methods. Iterative methods for solving linear systems. Diagonally dominant matrix. Jacobi method. Gauss-Seidel. Applications to problems of engineering.

3. EIGENVALUES AND EIGENVECTORS / 12 HOURS

Finding eigenvalues and eigenvectors, Gershgorin theorem. Positive definite matrix, Hermitian matrix. Theorems of eigenvalues and eigenvectors. Direct power up methods, reverse translation. Jacobi method. Generalized eigenvalues and eigenvectors problems.

4. **NUMERICAL INTERPOLATION / 6 HOURS**

   Existence and uniqueness of polynomial interpolation. Newton polynomial. Lagrange polynomial. Divided differences. Finite differences. Numerical derivation. Applications of numerical interpolation to solve difference equations. Discussion of vibration problems.

5. **NUMERICAL INTEGRATION / 6 HOURS**

   Newton-Cotes quadrature. Gauss-Legendre quadrature. Applications of numerical integration. Euler method for solve differential equations.

6. **INTRODUCTION TO THE FINITE ELEMENT METHOD / 3 HOURS**

   Assembly codes and the solution of a partial differential equation with the Finite Element method.

V. LABORATORY EXPERIENCES

Lab 1: MATLAB introduction, vectors, matrices and MATLAB commands.
Lab 2: MATLAB programming.
Lab 3: Application on an engineering problem by using the first units of the course.
Lab 4: Solving of a vibration problem.
Lab 5: Introduction into numerical simulation.
Lab 6: Programming of an engineering problem and numerical simulation.

VI. METHODOLOGY

Numerical Methods course is developed in lectures, classroom quizzes and laboratory experiences. The skills are gradually acquired and with the support of the computing center. In this laboratory, the student may observe and demonstrate that the theory is consistent with the computer and its results are subject to a margin of error according to the computer arithmetic and the degree of precision desired. At the beginning of each learning unit, the instructor states the objective of the topic to be developed by a brief introduction, explaining the practical applications which use the knowledge imparted and the importance of their study. The development of the subject becomes supported by multimedia, reprints and other audiovisual materials. The teaching is reinforced by the development of problems of varying degrees of difficulty, motivating students to develop their analytical skills. The instructor will absolve the doubts and queries of the students during the classes, seminars and tutorial hours. The students will use reprints of the theory, bibliography for each topic and will develop skills for the problems solved in seminars in order to be prepared for the classroom quizzes.

VII. EVALUATION FORMULA:

The average grade **PF** is calculated as follows:

PF = (EP + EF + PP) / 3 **PP = (∑3 better PA + ∑ 2 better PL + PC) / 6**

EP:	Mid-Term Exam	**PA**:	Classroom quizzes
EF:	Final Exam	**PL**:	Laboratory quizzes
PP:	Average of quizzes	**PC**:	Course Project

VIII. BIBLIOGRAPHY

1. **Richard L. Burden, J. Douglas Faires**
   Numerical Analysis
   BROOKS COLE CENGAGE Learning. 9º Edition

2. **J. Stoer, R. Bulirsch**
   Introduction to Numerical Analysis
   Springer, 2002

3. **Steven Chapra, Raymond Canale**
   Métodos Numéricos para Ingenieros
   McGraw-Hill, 2007

IX. COURSE CONTRIBUTIONS TO STUDENT OUTCOMES ATTAINMENT

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

K = Key **R** = Related Empty box = Does not apply

Outcome	Description	Contribution
Engineering Design	Design civil works satisfying requirements and needs as well as given constraints and limitations.	**R**
Problem solving	Identify, formulate and solve engineering problems properly using the methods, techniques and tools of civil engineering.	**R**
Sciences Application	Apply the knowledge and skills of mathematics, sciences and engineering to solve civil engineering problems.	**K**
Experimentation	Conceive and conduct experiments, analyze data and interpret results.	**R**
Modern Engineering	Use and apply techniques, methods and tools of modem engineering necessary for the practice of civil engineering.	**R**
Project Management	Plan and manage civil engineering projects taking into account efficiency and productivity criteria.	
Engineering Impact	Understand the impact of engineering solutions on people and society in local and global contexts.	
Environmental Appraisal	Takes into account the importance of preserving and improving the environment in the development of their personal and professional activities.	
Lifelong Learning	Recognize the need to keep their knowledge and skills up to date according to advances of civil engineering and engage in lifelong learning.	
Contemporary Issues	Know and analyze relevant contemporary issues in local, national and global contexts.	
Ethics and Professional Responsibility	Evaluate their decisions and actions from a moral perspective and assume responsibility for the executed projects.	
Communication	Communicate clearly and effectively in oral, written and graphical formats, interacting with different types of audiences.	
Team working	Appraise the importance of team working and participate actively and effectively in multidisciplinary teams.	