COLLEGE OF ENGINEERING
MECHANICAL AND ELECTRICAL DEPARTMENT

COURSE NAME: FINITE ELEMENT METHOD
COURSE ID: 5613
FACULTY CURSE ID: 5613
UNIVERSITY COURSE ID: 974
CACEI ID: AE
STUDY PLAN LEVEL:IX
CREDITS: 8
NORMAL HOURS PER WEEK: 4
TOTAL HOURS COURSE:64
LAB HOURS PER WEEK: 1
COMPLEMENTARY PRACTICES:
EXTRA-CLASS WORK HOURS / WEEK: 4
COURSE TYPE: E
APPROVED CREDITS NEEDED:
CURRICULAR LAST REVISION DATE: AUGUST 2010
PREREQUISITE COURSE:

COURSE JUSTIFICATION

THIS COURSE INCLUDES THE BASICS FOR NONLINEAR PROBLEM SOLUTIONS, WHICH ARE THE MAJOR PART OF THE PROBLEMS IN ENGINEERING.
THE FINITE ELEMENT METHOD (FEM) IS A NUMERICAL METHOD WHICH PROVIDES MORE FLEXIBILITY TO MODEL COMPLEX GEOMETRIES TAN THE FINITE DIFFERENCES AND FINITE VOLUME METHODS. IT IS WIDELY USED TO SOLVE PROBLEMS IN THE FIELDS OF STRUCTURES, MECHANICS OF MATERIALS, HEAT TRANSFER AND FLUID DYNAMICS, AS WELL AS MANY OTHER DISCIPLINES. THEREFORE, THE MECHANICAL AND ELECTRICAL ENGINEERING DEPARTMENT OFFERS THIS ALTERNATIVE FOR THE STUDENT TO GET FAMILIAR WITH THE FEM.

COURSE OBJECTIVE

AFTER COMPLETING THE COURSE THE STUDENT WILL GET THE FOUNDATIONS ON THE FORMULATION OF THE FINITE ELEMENT METHOD AND ON THE APPROPRIATE THE USE OF MATHEMATICS AND COMPUTER TOOLS FOR ANALYSIS OF PROBLEMS IN HEAT TRANSFER AND MECHANICS OF MATERIALS.

COURSE TOPICS

UNIT 1
PRESENTATION

OBJECTIVE: STUDENTS WILL BECOME FAMILIAR WITH THE APPLICATIONS OF FEM.
TOPICS:

1.1 HISTORIC AND PANORAMIC OVERVIEW AND APPLICATIONS OF THE COURSE CONTENTS.

UNIT 2
DIRECT METHOD FOR THE FORMULATION OF FINITE ELEMENT METHOD FOR 1D PROBLEM

OBJECTIVE: TO UNDERSTAND THE FUNDAMENTALS OF FEM.
TOPICS:

2.1 ENERGETIC FORMULATION FOR ONE DIMENSIONAL ELEMENT
(BARS AND SPRINGS).
2.2 ONE DIMENSIONAL ELEMENT ASSEMBLY. (TRUSSES).
2.3 MATRIX SOLUTION OF TRUSSES.
2.4 BOUNDARY CONDITIONS.
2.5 APPLICATION EXAMPLES.

UNIT 3
VARIATIONAL METHODS OF SOLUTION FOR SECOND ORDER DIFFERENTIAL EQUATIONS

OBJECTIVE: TO UNDERSTAND THE PRINCIPLES OF VARIATIONAL METHODS TO ANALYZE PROBLEMS IN A CONTINUUM.

TOPICS:
3.1 MODELING OF PROBLEMS WITH BOUNDARY CONDITIONS.
3.2 EXAMPLES OF THE SECOND ORDER PROBLEMS IN ONE DIMENSION.
3.3 WEIGHTED RESIDUAL METHOD, LEAST SQUARED METHOD, COLLOCATION METHOD AND GALERKIN METHOD.
3.4 WEAK FORMULATION OF PROBLEMS WITH BOUNDARY CONDITIONS. RAYLEIGH-RITZ SOLUTION.

UNIT 4
GENERAL FORMULATION WITH FEM.

OBJECTIVE: TO UNDERSTAND THE METHODOLOGY OF FEM FOR ONE-DIMENSIONAL PROBLEMS.

TOPICS:

4.1 DESCRIPTION OF FEM.
4.2 FORMULATION FOR A 1D LINEAR ELEMENT.
4.3 ELEMENT ASSEMBLY.
4.4 INTRODUCTION OF BOUNDARY CONDITIONS.

4.5 SOLUTION OF THE SYSTEM OF EQUATIONS.
4.6 POST-PROCESSING.
4.7 GENERAL PROBLEMS WITH FEM MODELING. (CONVERGENCE, MESHING SUGGESTIONS, ETC.)

UNIT 5
GENERAL FORMULATION OF FEM FOR TWO-DIMENSIONAL PROBLEMS

OBJECTIVE: ANALYZE 2D PROBLEMS USING MEF.

TOPICS:
5.1 PROBLEMS WITH BOUNDARY CONDITIONS. THE MODEL EQUATION.
5.2 DISCRETIZATION USING TWO-DIMENSIONAL LINEAR FINITE ELEMENTS.
5.3 DERIAVATION OF RAYLEIGH -RITZ ,2D ELEMENT EQUATIONS
5.4 ELEMENT EQUATIONS ASSEMBLY.
5.5 IMPOSITION OF BOUNDARY CONDITIONS.
5.6 SOLUTION OF EQUATIONS.
5.7 SOME MODELING CONSIDERATIONS.

UNIT 6
ANALYSIS OF HEAT TRANSFER PROBLEMS

OBJECTIVE: ANALYZE STEADY-STATE THERMAL PROBLEMS USING FEM.

TOPICS:
6.1 INTRODUCTION TO CONDUCTION PROBLEMS IN HEAT TRANSFER.
FEM MODELING FOR HEAT CONDUCTION PROBLEMS (SCALAR FIELD).
6.2 NATURAL (CONVECTIVE) AND ESSENTIAL BOUNDARY CONDITIONS MODELING.
6.3 APPLICATIONS TO HEAT CONDUCTION.
6.4 SOLUTION OF HEAT TRANSFER PROBLEMS WITH LINEAR TRIANGULAR ELEMENTS USING COMMERCIAL SOFTWARE AND ITS ANALYTICAL VALIDATION.
6.5 APPLICATIONS THAT DO NOT ADMIT ANALYTICAL SOLUTION (COMPLEX GEOMETRIES OR NONLINEAR BEHAVIOR) USING A FEM COMMERCIAL SOFTWARE.

METODOLOGY

PRESENTATION OF TOPICS, ANALYSIS OF THEORETICAL CONCEPTS, USE OF COMMERCIAL CODES, TEAM AND INDIVIDUAL WORK.
WEEKLY PRACTICE IN THE APPLIED COMPUTING LAB WITH COMMERCIAL SOFTWARE.

EVALUATION CRITERIA

EVALUATION ACCORDING TO THE INSTITUTIONAL RULES MUST INCLUDE FOUR DEPARTMENTAL EXAMS, SO THE COURSE EVALUATION WILL BE AS FOLLOWS:
EXAMS 80%
TASKS OR RESEARCH 20%

BIBLIOGRAPHY

REDDY J.N., AN INTRODUCTION TO THE FINITE ELEMENT METHOD. MC GRAW-HILL, U.S.A., 2006.

BIBLIOGRAFÍA COMPLEMENTARÍA:

IAN M. SMITH, VAUGHAN RIFFITHS.,PROGRAMMING THE FINITE ELEMENT METHOD , JOHN WILEY & SONS; 4 EDITION (NOVEMBER 15, 2004)

BATHE KLAUS-JURGEN .,FINITE ELEMENT PROCEDURES ,
PRENTICE-HALL 1995

MOAVENI SAEED., FINITE ELEMENT ANALYSIS: THEORY AND APPLICATIONS WITH ANSYS, SECOND EDITION ,
PRENTICE HALL , 2 EDITION (JANUARY 6, 2003)

BUCHANAN GEORGE R., SCHAUM'S OUTLINE OF FINITE ELEMENT ANALYSIS, 1 EDITION (NOVEMBER 1, 1994)
BURDEN RICHARD & J. DOUGLAS FAIRES
ANÁLISIS NUMÉRICO. GRUPO EDITORIAL IBEROAMÉRICA.

COOK MALKUS PLESA, CONCEPTS AND APLICATIONS OF
FINITE ELEMENT ANALYSIS, 3TH. EDITION, JOHN WILEY & SONS,
1989.
KIKUCHI NOBURU, FINITE ELEMENT METHODS IN MECHANICS, CAMBRIDGE UNIVERSITY PRESS.
ROSS C.T.F., FINITE ELEMENT METHODS IN ENGINEERING
SCIENCE. ELLIS HORWOOD SERIES IN MECHANICAL ENGINEERING.

ZIENKIEWICZ O.C., THE FINITE ELEMENT METHOD,
VOLUME 1, 4TH. EDITION, MC GRAW-HILL INTERNATIONAL,
1989.

SOFTWARE AND TICS

SOFTWARE TO USE:

NASTRAN NX

INSTRUCTOR'S OR COURSE COORDINATOR'S NAME:

DRA. NANCY VISAIRO CRUZ