University of Puerto Rico
Mayagüez Campus
College of Engineering
Department of Mechanical Engineering
M.S./Ph.D. in Mechanical Engineering

Course Syllabus

1. General Information:

Alpha-numeric codification: INME 6037
Course Title: Finite Element Analysis
Number of credits: 3
Contact Period: Three hours of lecture per week

2. Course Description:

English: Application of energy and variational principles to approximate ordinary and partial differential equations. Application of weak and strong formulations. Application to structural and heat transfer problems with static and dynamic loading. Computer programming of finite element analysis code to solve one-and two-dimensional problems using isoparametric formulation. Comparison of finite element results with exact and semi-analytical solutions.

Spanish: Aplicación de principios energéticos y variacionales para aproximar ecuaciones diferenciales, ordinarias y parciales. Aplicación de formulaciones fuertes y débiles. Aplicación a problemas estructurales y de transferencia de calor con cargadas estáticas y dinámicas. Programación en computadoras de un código de elementos finitos para resolver problemas en uno y dos dimensiones usando la formulación isoparametrica. Comparación de resultados de elementos finitos con la solución exacta y semi analítica.

3. Pre/Co-requisites and other requirements:

Pre-requisite: Authorization of the Director of the Department

4. Course Objectives:

- Applying energy and variational principles to solve partial and ordinary differential equations;
- Understanding relationships between stresses, strains, displacements, material properties, and external loads;
- Evaluating differential equations using strong and weak formulations;
- Creating a computer code using pre-processing, processing and post-processing to solve spring assembly structure;
- Formulating and solving second and fourth order ordinary differential equations using isoparametric formulation using a finite element computer code;
- Formulating and solving second order partial differential equations using isoparametric formulation using a finite element computer code;
- Formulating and solving axisymmetric problems using a finite element computer code;
- Formulating and solving dynamic problems (free-vibration and transient) using a finite element computer code.

5. Instructional Strategies:

☒conference ☒discussion ☐computation ☐laboratory

☐seminar with formal presentation ☐seminar without formal presentation ☐workshop

☐art workshop ☐practice ☐trip ☐thesis ☐special problems ☐tutoring

☐research ☐other, please specify:

6. Minimum or Required Resources Available:

None

7. Course time frame and thematic outline

General Topics	Contact Hours
I. Review of Apply Elasticity	
a. State of stress and strain	0.5
b. Equilibrium Equations	0.5
c. Constitutive Relationships	0.5
d. Strain-Displacement Equations	0.5
II. Energy and Variational Principles	
a. Exact solution to differential equations	0.5
b. Strong Formulations	2
c. Weak Formulations	2
d. Principle of Minimum Total Potential Energy	1
e. Principle of Virtual Work (optional)	1
III. Direct Stiffness Method	
a. Basic concepts of structural modeling	1
b. Review of the stiffness method of structural analysis.	1
c. Solution using spring assemblies: Preprocessor, processor, postprocessor	1
d. Computer Program Implementation	1
IV. Second Order Ordinary Differential Equations	
a. Finite Element Representation	3
b. Solution using preprocessor, processor, postprocessor	1
c. Computer Program Implementation	1
d. Application to bars and heat transfer problems	2
V. Fourth Order Ordinary Differential Equations	
a. Finite Element Representation	3
b. Solution using preprocessor, processor, postprocessor	1
c. Computer Program Implementation	1
d. Application to beams and frames	2
VI. Second Order Partial Differential Equations	
a. Finite Element Representation	2
b. Solution using preprocessor, processor, postprocessor	1
c. Computer Program Implementation	1
d. Application to structural plane and heat transfer problems using triangular and quadrilateral elements	2

VII. Axisymmetric Problems	
a. Finite Element Representation	2
b. Solution using preprocessor, processor, postprocessor	1
c. Computer Program Implementation	1
d. Application to structural plane and heat transfer problems using triangular and quadrilateral elements	1
VIII. Dynamic Problems	
a. Finite Element Representation	3
b. Solution using preprocessor, processor, postprocessor	1
c. Computer Program Implementation	1
d. Application to spring, structural, and heat transfer problems using linear, triangular and quadrilateral elements	1
Test	1.5
Total hours: (equivalent to contact period)	**45**

8. Grading System

☒Quantifiable (S/NS) ☐ Not Quantifiable

9. Evaluation Strategies

	Quantity	**Percent**
☒ **Exams**	**2**	**40**
☒ **Final Exam**	**1**	**20**
☐ **Short Quizzes**		
☒ **Oral Reports**	**1**	**20**
☐ **Monographies**		
☐ **Portfolio**		
☒ **Projects**	**1**	**20**
☐ **Journals**		
☐ **Other, specify:**		
TOTAL:		**100%**

10. Bibliography:

Textbook:

Oden J. T., and J. N. Reddy. 2011. *An Introduction to the Mathematical Theory of Finite Elements*. New York: Dover Publications. [Available at the Circulation Collection (QA379. O3 2011), UPRM General Library]

Other resources:

1. Reddy, J. N. 2006. *An Introduction to the Finite Element Method.* New York: McGraw-Hill Book Company. [Available at the Circulation Collection (TA347.F5 R4 2006), UPRM General Library] (**)
2. Wunderlich, W. and Walter D. Pilkey, 2002. *Mechanics of Structures: Variational and Computational Methods*. Florida: CRC Press. http://dx.doi.org/10.1201/9781420041835. [Available via MechanicalENGINEERINGnetBASE, UPRM General Library Databases] (*)
3. Bhatti, M. Asghar. 2006. *Advanced Topics in Finite Element Analysis of Structures: With Mathematica and MATLAB Computations*. New Jersey: John Wiley & Sons. [Available at the Circulation Collection (TA647. B494 2006), UPRM General Library] (**)
4. Ferreira, A.J.M. 2009. *MATLAB Codes for Finite Element Analysis*. New York: Springer.

http://dx.doi.org/ 10.1007/978-1-4020-9200-8. [Available via Springer eBooks, UPRM General Library Databases].

5. Electronic resources available through the Library's website: http://www.uprm.edu/library/cre/listdbsp.php?l=1&st=0&topic=77.

* These are classical handbooks
** These books are key classic references and remain as the top books for the subjects covered in the course and there are no up-to-date textbooks to substitute these books.

11. Law 51: The Comprehensive Educational Services Act for People with Disabilities:
States that after identifying with the instructor and the institution, the student with disabilities will receive reasonable accommodation in their courses and evaluations. For more information, contact the Department of Counseling and Psychological services at the Office of the Dean of Students (Office DE 21) or call 787-265-3864 or 787-832-4040 x 3772, 2040 and 3864.

12. Academic Integrity
The University of Puerto Rico promotes the highest standards of academic and scientific integrity. Article 6.2 of the UPR Students General Bylaws (Board of Trustees Certification 13, 2009-2010) states that academic dishonesty includes, but is not limited to: fraudulent actions; obtaining grades or academic degrees by false or fraudulent simulations; copying the whole or part of the academic work of another person; plagiarizing totally or partially the work of another person; copying all or part of another person answers to the questions of an oral or written exam by taking or getting someone else to take the exam on his/her behalf; as well as enabling and facilitating another person to perform the aforementioned behavior. Any of these behaviors will be subject to disciplinary action in accordance with the disciplinary procedure laid down in the UPR Students General Bylaws. ─

13. Certification 06-43 of the Academic Senate
"The academic guidelines for offering online courses," defines: Traditional face-to-face courses are those that have less than 25% of the course's regular contact hours via the Internet. Therefore, a three-credit course will be considered "face to face" if, of the 45 hours of regular contact, 11 or less are taught via the Internet. According to certification 06-43 of the Academic Senate, a course may include up to 25% of its total contact hours via the Internet. The objective of this is so that all professors have this alternative in the case of any unscheduled eventuality.

14. Sexual Harassment: Certification 130-2014-2015 states:
Sexual harassment in the workplace and in the study environment is an illegal and discriminatory act and is against the best interests of the University of Puerto Rico. All persons who understand they have been subject to acts of sexual harassment at the University of Puerto Rico may file a complaint and request that the institution investigate, where necessary, and assume the corresponding action by the university authorities. If the complainant is a student, he or she must refer his or her complaint to the Office of the Student Ombudsperson or that of the Dean of Students.

Revised: February, 2019