Texas A&M University
Departmental Request for a New Course
Undergraduate • Graduate • Professional

1. This request is submitted by the Department of ______________ AEROSPACE ENGINEERING ______________

2. Course prefix, number and complete title of course: MEMA 649 - Generalized Finite Element Methods

3. Course description (not more than 50 words): Systematic introduction to the theory and practice of generalized finite element (FE) methods, including GFEM, the hp-cloud method, particle methods and various meshless methods with similar character; precise formulation of the methods are presented; known theoretical results for convergence; important issues related to implementation, issues of numerical integration.

4. Prerequisite(s) ______________ Graduate student status ______________ Cross-listed with ______________ AERO 649 ______________

5. Is this a variable credit course? ☐ Yes ☑ No If yes, from __________ to __________.

6. Is this a repeatable course? ☐ Yes ☑ No If yes, this course may be taken ______ times. Will the course be repeated within the same semester/term? ☐ Yes ☑ No

7. Has this course been taught as a 289/489/689? ☑ Yes ☐ No If yes, how many times? __________ Indicate the number of students enrolled for each academic period it was taught. 05C - 7, 07A - 7

8. This course will be:
   a. required for students enrolled in the following degree program(s) (e.g., B.A. in history)

   b. an elective for students enrolled in the following degree program(s) (e.g., M.S., Ph.D. in geography) Aerospace engineering and related engineering

9. If other departments are teaching or are responsible for related subject matter, the course must be coordinated with these departments. Attach approval letters.

10. Prefix ______________ Course # ______________ Title (excluding punctuation) MEMA 649 GEN FINITE ELEMENT METH


Approval recommended by:

Head of Department Walter E. Haister - AERO Date 3/6-08

Head of Department (if cross-listed course) Date 3/6/08

Submitted to Coordinating Board by:

Director of Academic Support Services

Questions regarding this form should be directed to Sandra Williams at 845-8836.
OAR/AS - 04/07
MEMA 649 – Generalized Finite Element Methods
Credit 3: (3-0)

Instructor: Dr. Theofanis Strouboulis, Professor, Aerospace Engineering Dept., 746B HRBB, (979) 845-1676, strouboulis@aero.tamu.edu

Textbook Required: Course notes will be provided by the instructor.

Prerequisites: Graduate student status.

Attendance Policy: Students are expected to attend class.

Course Description: This course will provide a systematic introduction to the theory and practice of generalized finite element method, particle, discontinuous Galerkin and other related and will cover the formulation, theory, implementation and practice of the GFEM, the hp-cloud method, particle methods, the discontinuous enrichment and various other methods with similar character. The precise formulation of the methods will be presented, along with known theoretical results about their convergence, and important issues related to their implementation, especially the issues of numerical integration, the effect of the roundoff error and the problem of verification of the results using guaranteed bounds.

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

1) To understand the theoretical basis of the various generalized finite element methods, particle, discontinuous Galerkin, multiscale fem, discontinuous Galerkin, discontinuous enrichment method, the variational theory of complex rays, meshless and other related methods.
2) To be able to formulate and implement the Partition of Unity Method for the problems of heat conduction, elasticity, harmonic waves and other similar problems.
3) To be able to analyze the results obtained by one of the above mentioned methods based on the available theory
4) To employ various a-posteriori estimation approaches including the construction of guaranteed bounds for verifying the results obtained by one of the above methods.
5) To understand the assumptions, range of applicability, merits and limitations of the above mentioned computational methods.

Topics and Hours

<table>
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<tr>
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<th>Topics</th>
<th>Hours</th>
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<tbody>
<tr>
<td>1</td>
<td>The theory and practice of the Partition of Unity Method (PUM). (Lecture 1-6)</td>
<td>6</td>
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<td>2</td>
<td>The formulation of the PUM for the Laplace, the elasticity, and Helmholtz problems: the problem of the choice of local basis. (Lecture 7-12)</td>
<td>6</td>
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<td>3</td>
<td>The Generalized FEM (GFEM) as a PUM extension of the classical FEM and its implementation, and the Verification of the computed outputs via guaranteed bounds. (Lecture 13-22)</td>
<td>10</td>
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<td>4</td>
<td>The theory and practice of Particle Methods. (Lecture 23-25)</td>
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<td>5</td>
<td>The problem of numerical integration for generalized finite element and meshless methods. (Lecture 26-28)</td>
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<td>6</td>
<td>The theory and practice of other related methods, e.g. eXtended FEM (XFEM), Discontinuous Galerkin Method (DGFEM), Multiscale Finite Element Methods (MsFEM), Discontinuous Enrichment Method (DEM), Variational Theory of Complex Rays (VTCR), hp-cloud etc, their implementation issues, and applications (Lecture 28-42)</td>
<td>12</td>
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Method of Evaluation:

Projects 40%
Homework 40%
Final Exam 20%
Total 100%

Grading to be based on individual projects related to various aspects of generalized finite element methods and their implementations.

Contributions to Professional Component:

1. Prepares students to understand the theory and practice of modern computational methods.
2. Builds on foundation established by learning the classical finite element, finite difference methods
3. Teaches students the rudiments of implementation of generalized FEM, particle, discontinuous Galerkin, and other methods with similar character.
4. Prepares student to have knowledge of how to verify computed solutions by utilizing the underlying theory in the maximal possible extent.

Relationship to Program Outcomes:

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<tr>
<th>Objectives</th>
<th>Assessment Method</th>
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<tr>
<td>Understanding the theory and practice of generalized, particle, discontinuous Galerkin, and other related methods</td>
<td>Homework, final exam</td>
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<tr>
<td>Learning the implementation of the partition of unity, particle, discontinuous Galerkin, and other related methods</td>
<td>Projects</td>
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<tr>
<td>To be able to analyze the results obtained by a code employing one of the above mentioned methods by employing the underlying theory.</td>
<td>Homework</td>
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<td>The ability to verify the accuracy of computed solutions by employing various a-posteriori error estimation approaches.</td>
<td>Homework, projects.</td>
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<td>The ability to understand and monitor the effect of the numerical integration and roundoff error.</td>
<td>Homework</td>
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<tr>
<td>The ability to employ local bases based on handbook computations to improve the accuracy of computational methods for boundary-value problems</td>
<td>Projects</td>
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Americans with Disabilities Act
The Americans with Disabilities Act (ADA) is a federal antidiscrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact the Department of Student Life, Services for Students with Disabilities in Room B118 Cain Hall, or call 845-1637.

Copyrights
The handouts used in this course are copyrighted. By "handouts" we mean all materials generated for this class, which include but are not limited to syllabi, lab problems, in-class materials, review sheets, and additional problem sets. Because these materials are copyrighted, you do not have the right to copy the handouts, unless the author expressly grants permission.

Scholastic Integrity
As commonly defined, plagiarism consists of passing off as one's own the ideas, work, writings, etc., that belong to another. In accordance with this definition, you are committing plagiarism if you copy the work of another person and turn it in as your own, even if you have the permission of that person. Plagiarism is one of the worst academic sins, for the plagiarist destroys the trust among colleagues without which research cannot be safely communicated. If you have questions regarding plagiarism, please consult the latest issue of the Texas A&M University Student Rules [http://student-rules.tamu.edu/], under the section "Scholastic Dishonesty."