Course Approval Form

For instructions see:
http://registrar.gmu.edu/facultystaff/catalog-revisions/course/

Action Requested:

[x] Create new course [ ] Inactivate existing course

[ ] Modify existing course (check all that apply)

[ ] Title [ ] Credits [ ] Repeat Status [ ] Grade Type
[ ] Prereq/coreq [ ] Schedule Type [ ] Restrictions
[ ] Other:

Course Level:

[ ] Undergraduate
[x] Graduate

College/School: College of Sciences **Department:** Physics and Astronomy
Submitted by: Chi Yang **Ext:** 3-4077 **Email:** cyang@gmu.edu

Subject Code: PHYS **Number:** 640
(Do not list multiple codes or numbers. Each course proposal must have a separate form.)

Effective Term: [x] Fall [ ] Spring [ ] Summer *Year* 2017

Title:
Current: N/A
Banner (30 characters max w/ spaces):
New: Finite Element Analysis of Solids and Fluids

Fulfills Mason Core Req? (undergrad only)
[ ] Currently fulfills requirement
[ ] Submission in progress

Credits: (check one) [3] Fixed [ ] Variable or to

Repeat Status: (check one)
[x] Not Repeatable (NR)
[ ] Repeatable within degree (RD)
[ ] Repeatable within term (RT)
Maximum credits allowed: 3

Grade Mode: (check one)
[x] Regular (A, B, C, etc.)
[ ] Satisfactory/No Credit
[ ] Special (A, B C, etc. +IP)

Schedule Type: (check one) LEC can include LAB or RCT
[x] Lecture (LEC)
[ ] Lab (LAB)
[ ] Recitation (RCT)
[ ] Internship (INT)
[ ] Independent Study (IND)
[ ] Seminar (SEM)
[ ] Studio (STU)

Prerequisite(s):
PHYS 620 or permission of instructor

Corequisite(s):

Instructional Mode:
[x] 100% face-to-face
[ ] Hybrid: ≤ 50% electronically delivered
[ ] 100% electronically delivered

Restrictions Enforced by System: Major, College, Degree, Program, etc. (include code)

Equivalencies: (check only as applicable)
[ ] YES, course is 100% equivalent to:
[ ] YES, course is being renumbered to/will replace the following:

Catalog Copy for NEW Courses Only (Consult University Catalog for models)

Description (No more than 60 words, use verb phrases and present tense)	**Notes** (List additional information for the course)
Introduction to fundamentals of finite element analysis of solid, structural, fluid, and heat transfer problems. Topics include governing equations for heat transfer, solid and fluid mechanics; finite element formulation and solution procedures; appropriate use of finite element methods including setting up an appropriate model, interpreting results, and assessing solution error. Students are expected to develop their own finite element code.	

Indicate number of contact hours: Hours of Lecture or Seminar per week: 3 Hours of Lab or Studio:
When Offered: (check all that apply) [x] Fall [ ] Summer [ ] Spring

Approval Signatures

Department Approval Date

College/School Approval Date

If this course includes subject matter currently dealt with by any other units, the originating department must circulate this proposal for review by those units and obtain the necessary signatures prior to submission. Failure to do so will delay action on this proposal.

Unit Name	Unit Approval Name	Unit Approver's Signature	Date

For Graduate Courses Only

Graduate Council Member Provost Office Graduate Council Approval Date

For Registrar Office's Use Only: Banner_____Catalog_____

revised 6/22/15

Course Proposal Submitted to the College of Science Curriculum Committee (COSCC)

The form above is processed by the Office of the University Registrar. This second page is for the COSCC's reference. Please complete the applicable portions of this page to clearly communicate what the form above is requesting.

Course Number and Title:
PHYS 640, Finite Element Analysis of Solids and Fluids

Date of Departmental Approval: TBD

Course Prerequisites:
PHYS 620 (Continuum Mechanics) or permission of instructor

Catalog Description:
Introduction to fundamentals of finite element analysis of solid, structural, fluid, and heat transfer problems. Topics include governing equations for heat transfer, solid and fluid mechanics; finite element formulation and solution procedures; appropriate use of finite element methods including setting up an appropriate model, interpreting results, and assessing solution error. Students are expected to develop their own finite element code.

Reason for the New Course:
This new course will be one of the require electives for the new Engineering Physics concentration in our Physics Ph.D. Program. A corresponding Program Modification Proposal in expanding the scope of the current Physics Ph.D. Program by adding a new concentration in Engineering Physics is submitted together with this Course Approval Form. The main aim of this new course is to offer students interested in engineering physics fundamental knowledge in finite element method and its applications in the analysis of solid, structural, fluid, and heat transfer problems. In addition to providing students with the basics of the finite element technique, this course also provides a numerical tool for the solution of different classes of problems in heat transfer, solid mechanics and fluid mechanics. This course will prepare students with a necessary skill to solve complex real world problems in science and engineering using finite element method.

Prerequisite(s): PHYS 620 or permission of instructor

Hours of Lecture or Seminar per week: 3

Relationship to Existing Programs:
A proposal for modifying the current Physics Ph.D. Program by adding a new concentration in Engineering Physics is submitted together with this course proposal. The proposed Finite Element Analysis of Solids and Fluids course (PHYS 640) will be one of the required electives for the new concentration. PHYS 640 can also serve as an elective course for the graduate students in Bioengineering, Civil, Environmental, and Infrastructure Engineering, as well as Mechanical Engineering.

Relationship to Existing Courses:
There is a course in Finite Element Method, which is CSI 742, The Mathematics of the Finite Element Method. Students will be advised to take CSI 742 as a general elective if they are interested in the mathematical aspects of the Finite Element Method. PHYS can cross-list PHYS 640 with CSI 742 if the proposed course can serve the needs of CDS students.

Semester of Initial Offering:
Fall 2017.

Proposed Instructors:
Chi Yang, Cing-Dao Kan, Dhafer Marzougui, Fernando Camelli and Rainald Lohner

Tentative Syllabus for PHYS 640

Finite Element Analysis of Solids and Fluids

Contact Information

- Day(s) and Time:
- Location:
- Instructor:
- Email:
- Phone:
- Office Hour:
- Office:

Course Description

This course Introduces the fundamentals of finite element analysis of solid, structural, fluid, and heat transfer problems in a unified manner. Topics of the course include governing equations for heat transfer, solid and fluid mechanics; their finite element formulations and solution procedures; appropriate use of finite element methods including setting up an appropriate model, interpreting the results, and assessing the solution error.

The finite element methods studied in this course are practical procedures that are employed extensively in the mechanical, civil, ocean, automobile and aeronautical industries. The finite element methods are also becoming popular in simulation-based computer-aided designs. In addition to providing students with the basics of the finite element technique, this course also provides a numerical tool for the solution of different classes of problems in heat transfer, solid mechanics and fluid mechanics. This course will prepare students with a necessary skill to solve complex real world problems in science and engineering using finite element methods.

Students are expected to develop their own finite element code and complete a project for a given problem. Students will also have the opportunity to learn a commercial FEM package.

Course Prerequisites

PHYS 620 (Continuum Mechanics) or permission of instructor

Course Objectives

- To familiarize students with the general steps of finite element methods.
- To understand the basic finite element formulation techniques.
- To be able to derive equations in finite element methods for 1D, 2D and 3D problems.
- To be able to formulate and solve basic problems in heat transfer, solid mechanics and fluid mechanics.
- To be able to write computer program based on finite element methods.
- To be able to use FEM packages to solve basic engineering problems in heat transfer, solid mechanics and fluid mechanics.

Course Schedule

- Week 1: Introduction and basic concept of the finite element analysis
  Introduction to FEM package

Basic procedure (week 2 - 4)

- Week 2: Discretization and interpolation
  - Discretization of the domain
  - Interpolation models
  - High order and isotropic elements
- Week 3: Derivation of element matrices and vectors
  - Variational approach (Rayleigh-Ritz)
  - Weighted residual approach (Galerkin and least squares)
  - Derivation of finite element equations using various approaches
- Week 4: Finite element solution
  - Assembly of element matrices and vectors
  - Derivation of system equations
  - Numerical solution of finite element equations

Application to solid mechanics problems (week 5 – 9)

- Week 5: Basic equations and solution procedure
  - Basic equations of solid mechanics
  - Formulation of solid and structural mechanics
  - Formulation of finite element equations (static analysis)
- Week 6: Analysis of trusses, beams, and frames
  - Space truss element
  - Beam element
  - Space frame element
- Week 7: Analysis of plates
  - Triangular membrane element
  - Numerical results with membrane element
  - Quadratic triangle element
  - Rectangular plate element
  - Finite element of plates in bending
  - Analysis of three-dimensional structures using plate element
- Week 8: Analysis of three-dimensional problems
  - Tetrahedral element
  - Hexahedron element
  - Analysis of solids of revolution
- Week 9: Dynamic analysis
  - Dynamic equations of motion
  - Consistent and lumped matrices
  - Free vibration analysis
  - Dynamic response using finite element method

Application to heat transfer problems (week 10 – 11)

- Week 10:
  Formulation and solution procedure
  - Basic equations of heat transfer

- Derivation of finite element equations

One-dimensional problems

- Finite element formulation for one-dimensional conduction
- Finite element formulation for one-dimensional conduction with convection
- Unsteady state problems

- Week 11:

Two-dimensional problems

- Finite element formulation for heat transfer in two dimensions
- Unsteady state problems

Three-dimensional problems

- Finite element formulation for axisymmetric heat transfer
- Finite element formulation for heat transfer in three dimensions
- Unsteady state problems

Application to fluid mechanics problems (week 12 – 13)

- Week 12: Inviscid and incompressible flows
  - Governing equation for incompressible flow
  - Potential function formulation
  - Finite element solution using Galerkin approach
  - Stream function formulation
- Week 13: Viscous flows
  - Stream function formulation (using variational approach)
  - Velocity-pressure formulation (using Galerkin approach)
  - Solution of Navier-Stokes equations
- Week 14: Project presentation, Review and Discussion
- Week 15: Final Exam

Textbooks

- Singiresu S. Rao “The Finite Element Method in Engineering,” Fifth Edition, Elsevier Inc, 2011, ISBN: 978-1-85617-661-3.

References

- D.V. Hutton “Fundamentals of Finite Element Analysis,” McGraw Hill, 2004.
- J. Fish and T. Belytschko "A First Course in Finite Elements," J. Wiley, 2007.
- K.-J. Bathe “Finite Element Procedures, Prentice-Hall,” 1996.
- E. Madenci and I. Guven “The Finite Element Method and Applications in Engineering Using ANSYS,” Springer, 2015.
- Klaus-Jürgen Bathe. 2.092 Finite Element Analysis of Solids and Fluids I. Fall 2009. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.
- Klaus-Jürgen Bathe. 2.094 Finite Element Analysis of Solids and Fluids II. Spring 2011. Massachusetts Institute of Technology: MIT OpenCourseWare, https://ocw.mit.edu. License: Creative Commons BY-NC-SA.

Grading

- Homework 30%
- Project(s): 30%
- Final Exam: 40%

Course grade will be a letter grade. The following graduate grading is available at university catalog.

Grade	Quality Points	Graduate Courses
A+	4.00	Satisfactory/Passing
A	4.00	Satisfactory/Passing
A-	3.67	Satisfactory/Passing
B+	3.33	Satisfactory/Passing
B	3.00	Satisfactory/Passing
B-	2.67	Satisfactory/Passing
C	2.00	Unsatisfactory/Passing
F	0.00	Unsatisfactory/Failing

Academic Integrity

All students will be expected to abide by the Honor Code: Student members of the George Mason University community pledge not to cheat, plagiarize, steal, or lie in matters related to academic work. GMU honor code is available at http://oai.gmu.edu/the-mason-honor-code-2/.

University Policy

The University Catalog, http://catalog.gmu.edu, is the central resource for university policies affecting student, faculty, and staff conduct in university academic affairs. Other policies are available at http://universitypolicy.gmu.edu/.

Disability Accommodations

If you have a learning disability or other condition that may affect academic performance, please:
a) Make sure documentation is on file with Office of Disability Services (SUB I, Rm. 4205; 993-2474; http://ods.gmu.edu) to determine the accommodations you need; and
b) Talk with the instructor to discuss your accommodation needs.