Course Approval Form

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

Action Requested: (definitions available at website above)
[X] Create NEW [ ] Inactivate
[ ] Modify (check all that apply below)

[ ] Title (must be 75% similar to original) [ ] Repeat Status [ ] Prereq/coreq [ ] Grade Mode
[ ] Credits [ ] Schedule Type [ ] Restrictions [ ] Other: _____

Course Level:
[ ] Undergraduate [x] Graduate

College/School: College of Science **Department:** Physics and Astronomy
Submitted by: Fernando Camelli **Ext:** 4093 **Email:** fcamelli@gmu.edu

Subject Code: PHYS **Number:** 695
(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
Banner (30 characters max w/ spaces)
New: Applied Fluid Mechanics

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

Credits: (check one)
[X] Fixed → 3
[ ] Variable → to
[ ] Lec + Lab/Rct→ 0 or

Repeat Status: (check one)
[X] Not Repeatable (NR)
[ ] Repeatable within degree (RD) →
[ ] Repeatable within term (RT) →
Max credits allowed: (required for RT/RD status only)

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

Schedule Type: (check one)
LEC can include LAB or RCT if linked sections will be offered
[X] Lecture (LEC)
[ ] Lab (LAB)
[ ] Recitation (RCT)
[ ] Internship (INT)
[ ] Independent Study (IND)
[ ] Seminar (SEM)
[ ] Studio (STU)

Prerequisite(s) (NOTE: hard-coding requires separate Prereq Checking form; see above website):
PHYS 620 or PHYS 705 or permission of the instructor

Corequisite(s):

Restrictions Enforced by System: Major, College, Degree, Program, etc. Include Code(s).

Equivalencies (check only as applicable):
[ ] YES, course is 100% equivalent to
[ ] YES, course renumbered to or replaces

Catalog Copy (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 concepts of fluid mechanics and solving its equations using numerical techniques. The concepts and methods of computational fluid dynamics (CFD) will be introduced. Topics include fluid mechanics equations, spatial and temporal discretization, finite difference and finite volume schemes, accuracy and convergence. This course requires writing of code to solve the governing equations of fluid mechanics.	

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's Office

Graduate Council Approval Date

Form revised 9/14/2015

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.

FOR ALL COURSES (required)

Course Number and Title:

PHYS 695, Applied Fluid Mechanics

Date of Departmental Approval:

Reason for the New Course:

This new course will be one of the core requirements in the expanded scope for our new concentration in Engineering Physics in the PhD Program in Physics. A corresponding Program Modification Proposal in our PhD Program in 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 applied fluid mechanics with a flavor in computational fluid dynamics. This course will navigate a range of applications in the area of fluid mechanics. The course fills a need identified with students as well as employers in the industry. Furthermore, the concepts, relationships and workflows taught in this course will prove valuable in other fields of science applying computers to solve real life problems.

Prerequisite(s): PHYS 620 or PHYS 705 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 Applied Fluid Mechanics course (PHYS 695) will be one of the core courses for this new concentration. PHYS 695 can

also serve as an elective course for graduate students in Bioengineering, Civil, Environmental, and Infrastructure Engineering, as well as Mechanical Engineering.

Relationship to Existing Courses:
There are two high level courses, CSI 721 and CSI 722, which are based on advanced techniques on Computational Fluid Dynamics (CFD) and CSI 720 which is a lower level introduction to fluid mechanics. Students will be advised to take these courses as general electives if they are interested. PHYS can cross-list PHYS 695 with either CSI 720 or CSI 721 if the proposed course can serve the needs of CDS students.

Semester of Initial Offering:
Fall 2017

Proposed Instructors:
Rainald Löhner, Chi Yang, and Fernando Camelli.

Insert Tentative Syllabus Below

See next page

Tentative Syllabus for PHYS 695

Applied Fluid Mechanics

Contact Information

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

Course Description

This new course covers the application of fluid mechanics to current problems in science and industry. Topics to be covered include: a brief introduction to Cartesian tensors; conservation laws of mass, momentum, and energy, and derivation of the Navier-Stokes equations; description of compressible and incompressible flows; introduction to ideal and laminar flows; and an introduction to the basic physical and mathematical foundations of computational fluid dynamics. In addition, numerical methods of finite difference and finite volume schemes are presented to solve the Navier-Stokes equations. Students will be introduced to the art of writing computer codes to solve partial differential equations. An overview of mesh generation methods will be covered: Delaunay method and advancing front method. A series of applications of classic fluid mechanics problems will be introduced. For these real applications, the course will utilize a Computational Fluid Dynamics software package (open source or commercial), demonstrating the entire workflow of a simulation: setup, solution and visualization of flow problems.

Course Prerequisites

PHYS 620 (Continuum Mechanics) or PHYS 705 (Classical Mechanics) or permission of instructor

Course Objectives

- To learn fluid mechanics principles;
- To familiarize students with the derivation of numerical schemes to solve the partial differential equations describing flows, with particular emphasis on finite volume schemes;
- To learn coding, debugging and assess the accuracy of numerical schemes to solve the partial differential equations describing flows;
- To be able to use CFD packages in order to compute and evaluate complex 3-D flows in physics and engineering.

Course Schedule

- Week 1: Introduction to fundamental concepts in fluid mechanics.
- Week 2: Governing Equations: Conservation laws of fluid motion and boundary conditions.
- Week 3: Compressible and incompressible flows. Ideal and laminar flows.
- Week 4: Finite difference method (FDM): heat equation. Tessellating the computational domain.

- Week 5: Finite volume method (FVM): integral formulation, approximation of integrals.
- Week 6: FVM for diffusion problems.
- Week 7: FVM for convection and diffusion problems.
- Week 8: Mid-Term exam.
- Week 9: Solution algorithm for pressure-velocity coupling in steady flows.
- Week 10: FVM for unsteady flows.
- Week 11: Implementation of boundary conditions.
- Week 12: Application-Shallow waters equations.
- Week 13: Application-Renewable energy and fluid mechanics: wind turbines.
- Week 14: Review and discussion.
- Week 15: Final exam.

Textbooks

- P. K. Kundu, I. M. Cohen and D. R. Dowling, *Fluid Mechanics*, 6th Edition, Academic Press, 2015.
- H. K. Versteeg and W Malalasekera, *An Introduction to Computational Fluid Dynamics: The Finite Volume Method*, 2nd Edition, Pearson Education Limited, 2007.

References

- R. Löhner, *Applied CFD Techniques*, 2nd Edition, J. Wiley & Sons, 2008.
- R. J. Leveque, *Finite Volume Methods for Hyperbolic Problems*, Cambridge University Press, 2002.
- G. K. Batchelor, *An Introduction to Fluid Mechanics*, Cambridge University Press, reprinted 2002.
- K. A. Hoffmann and S. T. Chiang, *Computational Fluid Dynamics for Engineers*, Vols. 1 and 2, Engineering Education System, 1993.
- J.C. Tannehill, D. A. Anderson and R. H. Pletcher, *Computational Fluid Mechanics and Heat Transfer*, 2nd Edition, Taylor & Francis, 1997.
- C. Hirsch, *Numerical Computation of Internal and External Flows*, Vols. 1 and 2, Wiley, 1988.

Grading

- Homework/Project: 40%
- Midterm: 20%
- 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.

University Policy
University Policies: 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.