Course Approval Form

GEORGE MASON UNIVERSITY

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)

Course Level:
- [x] Undergraduate
- [ ] Graduate

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

College/School: COS
Department: Physics & Astronomy
Submitted by: Phil Rubin
Ext: 3815
Email: prubin@gmu.edu

Subject Code: PHYS **Number:** 164
(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	Computer Methods in Physics I

Fulfills Mason Core Req? (undergrad only)
- [ ] Currently fulfills requirement
- [x] 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)
- [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 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):
MATH 113

Corequisite(s):
MATH 114, PHYS 160 or PHYS 243

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)
Methods and techniques for solving physics problems using a computer. Complementing University Physics I, applications include kinematics, work, oscillations,and waves, data visualization, and error analysis.

Notes (List additional information for the course)

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 x Summer x 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

Undergraduate or Graduate Council Approval

UGC or GC Council Member — Provost's Office — UGC or GC Approval Date

Form revised 9/2/2016

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 164 – Computer Methods in Physics I

Date of Departmental Approval:

FOR NEW COURSES (required if creating a new course)

- Reason for the New Course: See attached
- Relationship to Existing Programs: Complements and supplements the first semester major course, University Physics I; will be a required of all physics majors
- Relationship to Existing Courses: Complements and supplements the first semester of the introductory physics sequence for majors, PHYS 160, by offering alternative approaches to solving similar problems; a more advanced course, PHYS 264, will similarly complement the second semester major course.
- Semester of Initial Offering: Spring 2017
- Proposed Instructors: Becker, Camelli, Kan, Löhner, Marzougui, Mishin, Nikolic, Rubin, Sheng, So, Summers, Weigel, Weingartner, Yang, Yiğit, Zhang, Zhao
- Insert Tentative Syllabus Below

PHYS 164: Computer Methods in Physics I

Syllabus

Instructor: Phil Rubin

Office: PH 253

Phone: 3815 (e-mail is better)

E-mail: prubin@gmu.edu

Office Hours: MW 8:30 – 10:00

Website: http://physics.gmu.edu/~rubinp/courses/164/

Required Text: Computational Physics, 2nd ed., Giordano and Nakanishi, Pearson Prentice Hall, 2006

Prerequisites: MATH 113 or CALC I equivalent

Co-requisite: MATH 114 or CALC II equivalent, PHYS 160 or PHYS 243

Requisites strictly enforced

Please note:

- All e-mail communication concerning this course will be between GMU accounts only.
- If you are a student with a disability and require academic accommodations, please see me and contact the O#ce of Disability Resources at 703.993.2474. All academic accommodations must be arranged through that office.

Course goals:

1. Learn to solve physical problems with basic numerical techniques
2. Gain familiarity with a programming language
3. Become adept at plotting and fitting data
4. Satisfy the Mason Core Information Technology (All) requirement
   - Students will be able to use technology to locate, access, evaluate, and use information, and appropriately cite resources from digital/electronic media.
   - Students will understand the core IT concepts in a range of current and emerging technologies and learn to apply appropriate technologies to a range of tasks.
   - Students will understand many of the key ethical, legal and social issues related to information technology and how to interpret and comply with ethical principles, laws, regulations, and institutional policies.
   - Students will understand the essential issues related to information security, how to take precautions and use techniques and tools to defend against computer crimes.

Expectations:

Homework: 70%
Project 20%
Quizzes: 5%
Classroom Participation: 5%

Homework will be program code listings, graphs, and numerical results solving the physical problems posed. Quizzes and class discussions will focus on the general information technology issues listed in the course goals.

Grading:

A+ = 100 – 96.67	A = 96.66 – 93.33	A- = 93.32 – 90.00
B+ = 89.99 – 86.67	B = 86.66 – 83.33	B- = 83.32 – 80.00
C+ = 79.99 – 76.67	C = 76.66 – 73.33	C- = 73.32 – 70.00
	D = 69.99 – 60.00	
	F = 59.99 – 0.00	

Tentative Schedule:

Week	Physical Problem	Numerical Technique	IT Topic	Resources
1	Introduction	MATLAB basics	Types of Resources	http://www.matrixlab-examples.com/matlab-tutorial.html (lessons 1-5) http://library.gmu.edu/tutorials/types-of-resources http://library.gmu.edu/sites/default/files/users/rstaffo2/PopularScholarlyTrade/PopularScholarlyTradeChart-CFerrance-20141203.pdf
2	One-dimensional motion	Euler	Networked Communi-cation	Text Ch 1, Appendix A https://staysafeonline.org/ https://stopthinkconnect.org/ https://www.youtube.com/playlist?list=PL13BDA056C386E83F http://www.onlineethics.org/Reso

				urces/netprivacy/scene1.aspx
3	One-dimensional motion	Runge-Kutta	Intellectual Property	Text Ch 1, Appendix A http://www.onlineethics.org/cms/12697.aspx http://www.onlineethics.org/Resources/32490/licensing.aspx http://audio-video.gnu.org/video/TEDxGE2014_Stallman05_LQ.webm http://universitypolicy.gmu.edu/policies/use-and-reproduction-of-copyrighted-materials/
4	Errors		Privacy	Text Appendix A https://stopthinkconnect.org/resources/preview/video-stop-think-connect-top-online-privacy-tips http://www.onlineethics.org/Resources/netprivacy/scene4.aspx http://itsecurity.gmu.edu/Alerts/upload/phishinfohandout-rev3c.pdf
5	Projectile Motion	Fitting Data to a Function	Security	Text Ch 2, Appendix D https://www.youtube.com/watch?v=fpx5mym4Lfg https://www.youtube.com/watch?v=O4xrTQyhr4g https://www.youtube.com/watch?v=yeepZr64XjU
6	Projectile Motion	Root Finding and Optimization	Reliability	Text Ch 2, Appendix D http://www.onlineethics.org/Resources/NSPEcases/ec96-4.aspx http://www.onlineethics.org/Resources/numericalprob/EE23.aspx
7		Spring Break		
8	The Solar System		Ethics	Text Ch 4

				http://integrity.gmu.edu/Ethics/upload/George-Mason-Code-of-Ethics.pdf http://itsecurity.gmu.edu/resources/practices.cfm http://universitypolicy.gmu.edu/policies/responsible-use-of-computing/ http://universitypolicy.gmu.edu/policies/wireless-networking/
9	The Solar System	Euler-Cromer		Text Ch 3 and 4, Appendix A
10	Oscillatory Motion			Text Ch 3
11	Oscillatory Motion			Text Ch 3
12	Vibrations and Waves	Linear Systems		Text Ch11, Appendix H
13	Vibrations and Waves			Text ChII, Appendix H
14		Projects		

Disruptive Behavior:

Misbehavior of any sort, including cell-phone use, unauthorized computer use, and eating or drinking in the laboratory or classroom, will not be tolerated. Such actions are grounds for dismissal from the classroom and the grading of a zero (0) on the assignment due that day. Cell phones must be turned off before entering the classroom and laboratory and remain off and out of sight.

Honor Code Violations:

Science is impossible when dishonesty, in any manifestation, exists. It's the worst possible conduct a scientist can display. Dishonesty of any sort (cheating, plagiarism, lying, stealing) will be reported to the honor council.

The GMU Honor Code: http://www.gmu.edu/catalog/9798/honorcod.html#code

Justification

Physics pedagogical literature has been touting the incorporation of computation into the physics introductory sequence for 25 years (see references). Associated theory and laboratory courses have long been employed to introduce basic physics concepts. It has now been shown that computational tools, appropriate to the discipline, can improve the learning of these concepts, sometimes more effectively than do laboratory exercises. On the other hand, it has also been shown that such tools can improve student performance in the physics laboratory. Multiple representations of similar problems promotes deeper understanding of the physics. This is not a matter of physics examples illustrating a computing method, but of physics computer methods as alternative ways to think about physics problems.

While much of the literature promotes packaged simulations, we desire, in addition to conceptual reinforcement, to prepare our students for physics research by their junior years. By writing code, students think through the physics of a problem, considering subtleties and complications, as they develop a useful skill. In writing code, students can come to realize the universal applicability of certain physics and mathematical concepts, such as how vectors behave, what integration means, how a trajectory is conceived in physics, that an inverse square law describes both gravitation and static electricity.

Our implementation of computational learning in the introductory physics sequence is based on the work of Ruth Chabay and Bruce Sherwood at North Carolina State University, but whereas Chabay and Sherwood incorporate computational physics exercises in the lecture course, necessitating a significant reduction of material covered, we propose associated courses, to allow more extensive developmental work and broader application to both theory and lab, without reducing the content of either of the other courses. Furthermore, while Chabay and Sherwood's implementation is based on 3D simulation software ,VPYTHON, we feel that Matlab and standard python are better tools for future work. In choosing exercises, we refer primarily to a more widely-used computational physics text.

Students taking these courses require mathematical and physics backgrounds commensurate with our introductory sequence. These courses are to be integrated into the introductory sequence. Instructors must be familiar with and attuned to what is being taught in the lecture and laboratory courses.

It may be worth noting that, while the majority of physics programs train their students in the computational methods of the field, our proposal is for our students to encounter such methods in the context of the foundational concepts and experimental techniques of physics as another way of understanding them.

References

http://dx.doi.org/10.1063/1.4822964
http://journals.aps.org/prper/pdf/10.1103/PhysRevSTPER.1.010103
http://dx.doi.org/10.1119/1.2150754
http://dx.doi.org/10.1119/1.2150766
http://dx.doi.org/10.1119/1.2835054
http://dx.doi.org/10.1119/1.3361987
http://dx.doi.org/10.1063/1.3679982
http://dx.doi.org/10.1119/1.4775536

Recent CDS 130 Syllabi

To be compared with the proposed PHYS 164 syllabus.

The syllabus below is a generic template for CDS 130. Instructor- and section-specific information (schedule, grading policy, announcements, etc.) may be found on your Instructor's page.

1. Brief Description

In this course, students will learn how to use computers to solve practical scientific problems. See the #Topics section of this syllabus for a list of specific topics.

2. Description

In this course, students learn to use a computer to solve scientific problems. No prior programming experience is required; an intuitive step-by-step approach is taken. Students

- Learn how a computer works internally;
- Learn basic programming concepts including assignment, conditional statements, iteration, arrays, and matrices;
- Use these programming concepts to develop simple simulations and implement models and algorithms using MATLAB;
- Develop and implement algorithms that solve problems encountered frequently in scientific computing involving image processing, pattern recognition, and numerical integration;
- Understand the importance and use of verification and validation;
- Understand several important concepts related to IT security and Ethics; and
- Use on-line scientific collaboration tools to work on group projects and contribute to class discussions.

3. Prerequisites

C or better in MATH 104 (http://catalog.gmu.edu/preview_course.php?catoid=17&coid=111584&print) , Trigonometry and Transcendental Functions, or MATH 105 (http://catalog.gmu.edu/preview_course.php?catoid=17&coid=111585&print) , Precalculus Mathematics, or passing score on the math placement test for MATH 110 (http://catalog.gmu.edu/preview_course.php?catoid=17&coid=111588&print) or MATH 113 (http://catalog.gmu.edu/preview_course.php?catoid=17&coid=111591&print) .

4. Text

None - no suitable textbook exists for this course. On-line notes and web-based content (including tutorial videos) will be used to supplement the lectures and in-class assignments. Feedback on past student evaluations has indicated that these materials were sufficient for success in this course and for understanding the material.

Several students have asked for books to read in order to prepare for class before the semester starts.

- The following books touch on some of the topics covered in CDS 130:
  - Code: The Hidden Language of Computer Hardware and Software (http://www.amazon.com/Code-Language-Computer-Hardware-Software/dp/0735611319/ref=pd_sim_b_7)

- The introduction of Head First Programming: A Learner's Guide to Programming Using the Python Language (http://www.amazon.com/Head-First-Programming-Learners-Language/dp/0596802374/ref=pd_sim_b_14)
- The introduction at [1] (http://ceee.rice.edu/Books/CS/chapter1/intro1.html)
- Programming in MATLAB: [2] (http://www.amazon.com/gp/search?index=books&linkCode=qs&keywords=0750687622) [3] (http://www.amazon.com/Essential-MATLAB-Scientists-Engineers-Second/dp/0750652403)

- The following textbooks cover many of the topics in CDS 130, but require a *much* higher background in math
  - Introduction to Computational Science [4] (http://www.amazon.com/Introduction-Computational-Science-Modeling-Simulation/dp/0691125651/ref=sr_1_1?ie=UTF8&qid=1293552290&sr=8-1)
  - Insight Through Computing [5] (http://www.ec-securehost.com/SIAM/OT117.html)

5. Topics

Topics covered in this course by category. Objective numbers given in parenthesis indicate the learning outcome(s) that the topic meets in #IT_Requirement. Each topic category heading includes in parenthesis the general category that the topic falls into among Computing, IT, and Science.

(Red links are pages that are under development and have not been posted.)

- Overview
  - Introduction

- Computer Fundamentals and Internals
  - Binary_Representation_of_Numbers
  - Binary_Addition
  - Encoding
  - Memory
  - Digitization
  - Computing_Limits
  - Transistors
  - Logic_Gates
  - A_Basic_Computer

- Tools
  - Introduction_To_MediaWiki
  - Digital_Notebooks
  - Screenshots

- Programming
  - Spreadsheets_vs_Programming_Languages
  - Introduction_To_MATLAB
  - Introduction_To_Octave
  - Assignment
  - Arrays
  - For_Loops
  - Iteration
  - Matrices

  - Nested_For_Loops
  - If_Statement

- Science Modeling
  - Modeling_Introduction
  - Science_Models
  - Mathematical_Models
  - Computational_Models

- Science Applications
  - Computational_Simulations
  - ODEs
  - Numerical_Integration
  - Verification
  - Validation

- Science Applications (Science and Gen Ed.)
  - Visualization_Overview
  - Images
  - Antialias
  - Tumor
  - Optimization

- Misc.
  - Ethics
  - passwords

6. Grading

See your instructor's syllabus

7. Honor Code

Your instructor enforces the honor code [6] (http://honorcode.gmu.edu/) :

> Student members of the George Mason University community pledge not to cheat, plagiarize, steal, or lie in matters related to academic work.

For more information see http://honorcode.gmu.edu/

The following paragraph was extracted from the document 2014_SYLLABUS_LANGUAGE.pdf attached to an email sent by the Provost.

> Mason is an Honor Code university; please see the University Catalog for a full description of the code and the honor committee process. The principle of academic integrity is taken very seriously and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form. Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for

guidance and clarification. In addition, you may not copy any text, computer code, image, data or any other material from the Internet or any other source and represent it as your own. Any material that is taken in whole or in part from any other source (including web-pages) that is not properly cited will be treated as a violation of Mason's academic honor code and will be submitted to the honor committee for adjudication, as will other violations of the honor code.

8. Software

Either MATLAB [7] (http://mathworks.com) or Octave [8] (http://octave.org) will be used, depending on instructor. Students may access and use MATLAB without charge either on campus or from any computer with an internet connection. Octave may be installed on your personal computer for free, but is not available in any of Mason's computer labs (see Introduction_To_Octave for installation instructions). A $109-dollar student version of MATLAB may be purchased at Patriot Computers [9] (http://compstore.gmu.edu/) and installed on your personal computer.

9. Schedule

See your instructor's page.

10. General Education

This is a general education course. From: [10] (http://provost.gmu.edu/gened/)

> Life, Liberty, and the Pursuit of Happiness" — this ringing phrase from the Declaration of Independence makes a fine statement about the ideals of General Education (or, as it is more classically called, liberal education) as we strive to articulate it at George Mason. Let's take the three parts of Thomas Jefferson's affirmation of humanity's "unalienable rights" and see how they apply to the goals of a general, or liberal, education.
>
> A liberal education prepares us for life's unpredictable, fascinating journey. One sobering truth about formal learning is that no matter how many courses we take or degrees we earn, we can't master every skill and possess every piece of knowledge that we need to succeed in a dynamic world. A liberal education proposes that the highest value of the college experience is the development of our ability to continue learning, adapting, creating, and responding to an ever-changing society and career environment. A liberal education is the most practical of all, because it never goes out of date; the habits of mind it fosters help us to stay current with our careers and the life of our times.
>
> A liberal education takes its name from this part of Jefferson's phrase; the root word for both the concept we so cherish and the education we practice is the Latin liber, meaning "free." So this kind of education is meant to increase our freedom—of thought and action, from prejudice and ignorance. It is the foundation stone of citizenship as Jefferson and his contemporaries envisioned that notion, a liberty built on rights, responsibilities, and respect for differences. A liberally educated person feels free to seek knowledge and wisdom from across the whole spectrum of human experience—free to challenge the assumptions of the past (and

also, after critical consideration, to accept them).

The liberal arts tradition provides its participants with tools for the pursuit of a happier, more engaged, more fulfilled life by putting ideals into action. The definition of happiness is personal; for some, an appreciation of "the best that has been thought and said"—or composed, constructed, painted, danced, or acted—is a necessary condition for happiness. For others, it might be an understanding of the wonder of the natural universe, the ever-changing ability of humans to create marvelous new inventions, or the complexities of the social fabric in an increasingly borderless world. For still others, it is a call to serve the community and the world in large and small ways, acting for the betterment of humanity. For most, it is some combination of the above. No matter the specifics: a liberal education offers the joy of discovery and the satisfaction of engagement with the largest questions of our time—and all time.

At Mason, we have created several ways to experience the excitement and gain the benefits of liberal education: the University General Education program; the New Century College Cornerstones; and, for a small group of outstanding students, the Honors College. Though their approaches are very different, as befits the creative spirit and diverse nature of our University, they are united in their commitment to the ideals of Life, Liberty, and the Pursuit of Happiness.

11. IT Requirement

This course fulfills the University's General Education "Information Technology with Ethics" (http://provost.gmu.edu/gened/requirements.html#it) requirement. These guidelines are copied below.

Guidelines and student learning outcomes for the IT requirement

Information Technology

Almost no area of academic, professional, or personal life is untouched by the information technology revolution. Success in college and beyond requires computer and information literacies that are flexible enough to change with a changing IT environment and adaptable to new problems and tasks.

The purpose of the information technology requirement is to ensure that students achieve an essential understanding of information technology infrastructure encompassing systems and devices; learn to make the most of the Web and other network resources; protect their digital data and devices; take advantage of latest technologies; and become more sophisticated technology users and consumers.

Courses meeting the "IT only" requirement must address learning outcomes 1 and 2, and one additional outcome. Courses meeting "IT with Ethics component" must address outcomes 1, 2, 3, and 5. Courses meeting the only IT Ethics component must address outcomes 3 and 5.

1. Students will be able to use technology to locate, access, evaluate, and use information, and appropriately cite resources from digital/electronic media.
2. Students will understand the core IT concepts in a range of current and emerging technologies and learn to apply appropriate technologies to a range of

tasks.
3. Students will understand many of the key ethical, legal and social issues related to information technology and how to interpret and comply with ethical principles, laws, regulations, and institutional policies.
4. Students will demonstrate the ability to communicate, create, and collaborate effectively using state-of-the-art information technologies in multiple modalities.
5. Students will understand the essential issues related to information security, how to take precautions and use techniques and tools to defend against computer crimes.

12. Student Resources

12.1. Email

Students must use their MasonLIVE email account to receive important University information, including messages related to this class. See http://masonlive.gmu.edu for more information.

12.2. Disability

If you are a student with a disability and you need academic accommodations, please see me and contact the Office of Disability Services (ODS) at 993-2474. All academic accommodations must be arranged through the ODS. http://ods.gmu.edu/

12.3. Writing

Mason's Writing Center is in A114 Robinson Hall; (703) 993-1200; http://writingcenter.gmu.edu/

12.4. Ask a librarian

http://library.gmu.edu/mudge/IM/IMRef.html

12.5. Psychological Services

Mason's Counseling and Psychological Services (CAPS): (703) 993-2380; http://caps.gmu.edu/

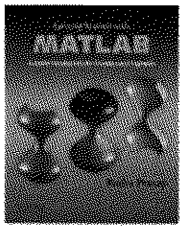
12.6. University Policies

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/. All members of the university community are responsible for knowing and following established policies.

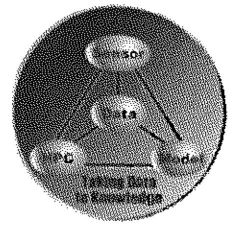
12.7. You read this far

Congratulations!

School of Physics, Astronomy, and Computational Sciences
George Mason University -- College of Science



CDS 130
Computing for Scientists
Spring Semester 2015



- *******IMPORTANT NOTE:** Last Day to Add Classes = January 27, 2015.
- **Course Syllabus Website:** http://kirkborne.net/cds130/
- **Supplemental Syllabus Information:**
  - Click for information regarding Disability Services, Counseling Services, Other Campus Resources, University Policies, University Catalog, and more.
  - Academic Skills Workshops
  - Hours of Operation for Campus Offices and Services
  - Academic Calendars (Semester Calendar, Final Exam Schedule)
- **Honor Code:**
  - Instructors may submit Exam Papers, Homework solutions, or any other student assignment to the SafeAssign plagiarism-detection service, in compliance with all of the following: GMU policy, Provost approval, and the GMU Honor Code.
  - Plagiarism will not be tolerated.
- **General Education:**
  - This class satisfies Mason's required "IT with Ethics component" General Education requirement: http://provost.gmu.edu/gened/general-education-requirements/.
  - Such courses are governed by the University General Education program: http://provost.gmu.edu/gened/.
  - Courses designed to meet the "IT with Ethics component" Gen Ed requirement must address these outcomes:
    1. Students will be able to use technology to locate, access, evaluate, and use information, and appropriately cite resources from digital/electronic media.
    2. Students will understand the core IT concepts in a range of current and emerging technologies and learn to apply appropriate technologies to a range of tasks.
    3. Students will understand many of the key ethical, legal and social issues related to information technology and how to interpret and comply with ethical principles, laws, regulations, and institutional policies.
    4. Students will understand the essential issues related to information security, how to take precautions and use techniques and tools to defend against computer crimes.

- **Lecture Day/Time:** (see https://patriotweb.gmu.edu/)
- **Lecture Place:** (see https://patriotweb.gmu.edu/) Innovation Hall ((Technology Enhanced Classroom with Student Computers))
- **Midterm Exam: TO BE ANNOUNCED** (in our classroom)
- **Final Exam: (UPDATED) TO BE ANNOUNCED** (in our classroom)
- **Grading:**
  - 50% = Class Exercises and Homework
  - 20% = Midterm Exam
  - 30% = Final Exam
- **Homework: *To be announced***
- **Reading Assignments: *To be announced* (there is no textbook for this course)**
- **Course Instructor:** Dr. Kirk Borne, Professor, Astrophysics and Computational Science
  - Office: Planetary Hall, Room 115, phone 703-993-8402 (with voicemail)
  - Office Hours: **by appointment**
  - Instructor's Travel Schedule: http://kirkborne.net/travel-schedule.htm
  - E-Mail: kborne(at)gmu(dot)edu (Students: http://masonlive.gmu.edu/) (Faculty: https://mso365.gmu.edu/)
  - Mailbox: Mailstop 6A2, Planetary Hall.

- **Online Course Material:** Please log into http://mymason.gmu.edu/ (**BLACKBOARD**) each week to get announcements, weekly lecture slides, and assignments.
- **Required Textbook:**
  - **NONE!** But, if you are interested in learning more..........
  - **Optional Supplemental Reading:**
    - *MATLAB: An Introduction With Applications*
    - *MATLAB Guide*
    - *Getting Started with MATLAB: A Quick Introduction for Scientists and Engineers*
- **Technology Requirements:**
  - Access to Internet. Active user accounts on **BLACKBOARD** and on http://masonlive.gmu.edu/.
  - Ability to operate a PC computer and standard deskstop applications, for use during class exercises.
- **Course Description (from GMU course catalog):**
  - **(3 Credits) Covers use of computers to solve practical scientific problems. Topics include creating effective scientific presentations, analysis of experimental data, online literature, data/information ethics, scientific modeling, and communication/collaboration tools. Designed to equip students with the knowledge and confidence they need to use future hardware and software systems both as students and throughout their scientific careers.** (Satisfies General Education Requirement: IT with Ethics component.)
- **Prerequisites:**
  1. Appropriate score on the math placement test.
- **Course Objectives:** By the end of the course, the student will be able to
  1. Use computers to investigate simple scientific problems using both modeling and simulation;
  2. Explain how models and simulations are used across the natural sciences, and understand their limitations;
  3. Solve simple scientific equations;
  4. Demonstrate how data are acquired, processed, analyzed, and visualized;
  5. Describe the connections between advances in computing and advances in the natural sciences; and
  6. Understand the principles and applications of IT Ethics.

Author: Kirk D. Borne
Last Update: **31 January 2015**

Welcome to CDS 130

Computing for Scientists (and Engineers)

Spring, 2015

Instructor: James Gentle

Lectures: Tuesdays and Thursdays 10:30am - 11:45am, Innovation Hall 222

If you send email to the instructor, please put "CDS 130" in the subject line.

You are responsible for checking your MasonLIVE email account regularly.

Learning Assistants:

Alayna Bigalbal
Office hours: Sunday 6:00pm-8:00pm, Planetary Hall 242.

Rebeca Orellana-Montano
Office hours: Wednesday 6:00pm-8:00pm, Planetary Hall 242.

Other help sessions open to all CDS 130 students will be held in Planetary Hall 242. See the general website for CDS 130.

Course Description

This course fulfills GMU's General Education "Information Technology with Ethics" requirement.

In this course students learn the fundamentals of the computational approach to scientific problem solving. No prior programming experience is required.

This course also counts for 3 credit hours of the 12 credits in CDS or CSI required for the Computational and Data Sciences minor.
Some other CDS courses are CDS 251: Introduction to Scientific Programming; CDS 301: Scientific Information and Data Visualization; CDS 302: Scientific Data and Databases; CDS 401: Scientific Data Mining; CDS 410: Numerical Analysis II; and CDS 411: Modeling and Simulation.

Objectives

- Learn how a computer stores and manipulates data.
- Learn basic programming concepts including assignment, conditional statements, iteration, arrays, and matrices.

  - The best way to do this is by using a real and useful programming language. We will use Matlab in this course.
  - When you learn to program in one system, you can learn other systems more easily -- but Matlab itself is very useful throughout science and engineering.
- Use these programming concepts to develop simple simulations and represent algorithms in a computer program.
- Develop and implement computational models that solve problems encountered frequently in scientific computing, such as stochastic simulations and numerical integration.
- Understand the importance and use of verification and validation.
- Understand important concepts related to IT security and ethics.

Prerequisites

A grade of C or better in MATH 104, Trigonometry and Transcendental Functions, or MATH 105, Precalculus Mathematics, or passing score on the math placement test for MATH 110 or MATH 113.

Text

None. On-line notes and web-based content will be used to supplement the lectures and in-class assignments.

Feedback on past student evaluations has indicated that these materials were sufficient for success in this course and for understanding the material.

Software

Matlab will be used.

Matlab is a very widely-used scientific software package that has many built-in functions, but that also provides a rich programming language. In this course, you will learn the basics of Matlab. The way to learn any software package or any programming language is by **using it.** Some of you will learn much more about Matlab than we will cover in this course. You may use it in other more advanced courses, or if you go on in your studies, you may use it as a research tool. If you want to learn more about Matlab beyond what we will cover in this course, the publisher of the software, MathWorks, provides some helpful tutorials. Their getting started guide is particularly useful.

Matlab is available on most GMU classroom computers and computers in student labs. For homework, you will usually have to print your solutions. Some of the student computer labs have printers.

Here is the list of labs. There is a "printers" link in the upper-right.

Students may also access and use Matlab without charge either on campus or from any computer with an internet connection using the GMU Virtual Computing Lab.
See comments on using VCL, and step-by-step screen shots.
If you use an Apple Mac computer, the instructions are slightly different.

Students may also purchase Matlab and install it on their own personal computers. Patriot Computers in the Johnson Center sells a student version of Matlab for $109.

Format of Classes

This is a three-credit course that meets for 75 minutes twice per week.
Some of the class time will be "activities", especially on Thursdays.

For each class, I will usually have much more material than I will actually cover.
How much I cover will depend on the number of questions and the amount of class discussion.
Because of this, from time to time, I will have to make adjustments to assignments that I may have already posted on the website.

Tuesday
Mostly lecture and some in-class activities.
Homework may be assigned at the end of class. It is usually an extension of the in-class activities.

Thursday
Lecture and in-class activities.
Often there will be a quiz near the start of class.
Homework is often assigned at the end of class. It is usually an extension of the in-class activities.

Attendance, Homework, Quizzes, Exams, Grading

Attendance

Although many notes will be posted on the web, this is not an "online" or "distance learning" class.

You are expected to attend every class (I do!), but I do not penalize students for missing class and I do not take attendance.

I believe that the grading policy sufficiently penalizes students for missing class, but it's up to you.

If you are unable to attend classes or if you feel that you are getting behind in your work, you should do something about it early in the semester.

This is true no matter what the excuse is.

There is not much that I can do if you come to me near the end of the semester and ask about doing "extra work" so you can pass the course. I hope you will always do extra work, but it's no substitute for the regular assigned work that all students are expected to do.

Homework

There will be several homework assignments.

In some cases, the homework will be due **at the beginning of class.**

Most homework will usually be hand-written, but it may involve computer output, especially later in the semester.

Late homework will not be accepted. I will drop the lowest homework grade.

It is OK to collaborate with other students on homework problems, however it is **not** OK to copy other students' work.

Homework questions will usually consist of calculations, short answers, and computer programs. The questions are designed to test a student's understanding of the course material.

When applicable, the student must write out both the solution and the step-by-step solution logic in their homework responses, so that instructors may assess the student's overall approach to and understanding of the assigned problems. Credit will be assigned on student homework based upon whether or not the student's solution is correct (approximately 50% of the score), and also whether the student's solution logic is correct (approximately 50% of the score).

Quizzes

There will be several short quizzes, usually near the beginning of the class.

Quizzes cannot be ``made-up''. (I post the solutions). I will drop the lowest quiz grade.

The quizzes will focus on the material covered on the previous Tuesday. They are not intended to be "cumulative", but they may involve concepts covered in earlier weeks.

Exams

A midterm and a final exam will be given in the class to test comprehension of the topics covered in the lecture, discussions, and homework.

Both exams are cumulative.

The exams will include short answers, multiple choice, and simple discussion questions. The questions will be based on concepts covered on the homeworks and in the in-class questions.

Sample midterm and final exams will be provided before the date of the actual exam.

I rarely give make-up exams. However, special consideration will be given if the student (1) has completed all of their home works on time and (2) provides compelling evidence that the exam was missed for reasons that were beyond the student's control.

Grading and Weighting

Partial credit may be given provided work is shown. When we grade, we look for a correct answer. If the answer is not correct, we look for evidence that you understood something about the problem. The more evidence that is provided, the more likely that partial credit will be given.

I drop the lowest quiz and the lowest homework grade.

Quizzes 15% (lowest quiz grade dropped)
Homework 30% (lowest HW grade dropped)
Midterm 25%
Final exam 30%

"Extra Work"

There are always some students who ask about doing "extra work", usually near the end of the semester. Students sometimes even say "do extra work for you". First of all, I do not expect students to work for me; I do my own work. I expect students to work for themselves.

I do want students to work hard, and I even hope that they will do "extra work" above and beyond the assigned homework, but I cannot really assign grades on "how much work" a student does or "how hard" a student works. To do so would involve a level of subjectivity completely inconsistent with my goal of objectivity and total fairness in how I deal with students in this class.

So, if you take this course, please keep up with the work, and if you find yourself falling behind, do something about it immediately. This may mean doing "extra work", but please don't ask for an adjustment in your grades based on "extra work".

Disabilities

Students with disabilities who need academic accommodations, please see the instructor and contact the Office of Disability Services (ODS) at 993-2474. All academic accommodations must be arranged through the ODS: http://ods.gmu.edu/.

George Mason provides Counseling and Psychological Services (CAPS) for students. Contact them at (703) 993-2380 or http://caps.gmu.edu/.

Academic Honor

Each student enrolled in this course must assume the responsibilities of an active participant in GMU's scholarly community in which everyone's academic work and behavior are held to the highest standards of honesty. The GMU policy on academic conduct will be followed in this course.

Collaborative Work

In this class, students are free to discuss homework problems or other topics with each other or anyone else, and are free to use any reference sources. Group work and discussion outside of class are encouraged, but of course explicit copying of homework solutions should not be done.

Note that other classes at GMU may have different restrictions on discussions among students relating to homework and course content.

Topics

- Overview
  - Introduction
- Computer Fundamentals and Internals
  - Binary Representation of Numbers (January 20, January 22January 27, HW 1, Quiz 1, Quiz 2)
  - Binary Addition (January 22)
  - Floating Point Representation of Numbers (January 29)
  - Representation of Other Types of Data (February 3)
- Programming
  - Introduction to Matlab (February 10)
  - Summary of Matlab Syntax (February 12)
  - Assignment Statements (February 10)
  - Logical Variables (February 12)
  - Numerical (Im)Precision (February 12)
  - Arrays: Matrices, Vectors(??), and Higher Dimensional Arrays (February 19, February 24)
  - Solving Linear Systems (February 24)
  - For Loops (March 19)
  - While Loops (March 24)
  - Conditional Statements: `if`, `else`, `elseif`, `end` (March 19)

  - Simple Graphics (February 24)
  - User-Written Functions (March 31, April 2)
    - Anonymous Functions
  - Nested For Loops (March 26)
- Math Topics
  - Matrices and Vectors; Multiplication of Matrices (February 19)
  - Computing Areas (April 16)
- Science Modeling
  - Models in Science (April 21)
    - Mathematical Models
    - Computational Models
  - Visualization and Use of Color (April 23, April 28)
    - Grayscale (April 28)
  - Random Processes (April 16)
  - Monte Carlo Methods and Simulation (April 16)
  - Numerical Analysis and Programming (April 23)
    - Verification
    - Validation
- Other Topics
  - Ethics (April 28, April 30)
  - Passwords and Computer Security (April 30)

Schedule

The details of the schedule will evolve as the semester progresses.

January 20

- Course overview
- Binary representation of numbers.
- Practicum on binary representation of numbers.
  Don't look at the solutions until you have spent some time working out the solutions yourself!
- Homework a. Print this page and put your solutions on it.

January 22

- Discuss Tuesday's practicum and Homework a solutions; grade your own.
- "quiz" (not to turn in).
  You could collaborate Tuesday --- but no collaboration now.
- Answers given; grade your own quiz.
- More on binary representation of numbers and arithmetic in the binary representation.
- Homework 1. Print this page and put your solutions on it.

- Homework 1 solution.

January 27

More on binary representation of numbers:

- Fixed point representation. (Material from Jan 22: questions? review?)
- Floating point representation.

January 29

- Review Homework 1; fixed positional notation.
- Quiz mainly on fixed point numbers.
- More on floating point numbers.
- Practicum: Working with floating point numbers.
- Homework 2. Print these pages and put your solutions on them.
    - Homework 2 solution.

February 3

- Review quiz (simple binary fixed point).
- Comments, questions on floating point numbers.
- Use of binary to represent other things: characters.
- Homework b: Use of binary to represent stuff.

February 5

- Review Homework 2.
- Review Homework b.
- Quiz mainly on floating point numbers and characters (like Homework b, but with smaller numbers!).
- Use of binary to represent other things: commands to the computer.
- Computer programs.
- Homework 3. May submit on February 10 without penalty.
    - Homework 3 solution.

February 10

- Review quiz.
- The computer as a calculator; Matlab.
    - Invoking Matlab. (See comments above.)
    - Variables in Matlab.
    - Assignment statements in Matlab.

  - Functions in Matlab: sqrt, sin, ...
  - Print Screen and the clipboard.
- How to access Matlab via GMU Virtual Computing Lab (VCL).
  More details about VCL: step-by-step screen shots.
  There are a couple small differences if using VCL from an Apple Mac computer. These are described in a user guide for the Mac.
  Connect to VCL.
- Homework 4. Due February 10. (See comments above for using Matlab.)
  - Homework 4 Solution.

February 12

- More simple computations and functions in Matlab:
  - character variables, logical variables
  - built-in (global) constants
  - workspace, clear
  - more built-in functions
  - See additional comments added after class.
- Homework 5.
  - Homework 5 solution.

February 17

Class cancelled due to weather.

February 19

- Matrices and vectors.
- Homework 6.
  - Homework 6 solution.

February 24

- The Matlab environment; VCL.
- Matrices and vectors.
  - Simple graphs of linear equations.
  - Solving systems of linear equations.
- Homework 7.
  - Homework 7 solution.

February 26

Class cancelled due to weather.

- ~~Quiz on matrices in Matlab.~~
- ~~Matlab: syntax, operators, help~~

March 3

- Practice quiz on matrices in Matlab.
  - Solutions a , b , c
- Matlab: review of basics
- Review for midterm.
  - Topics.
  - Sample exam.

March 5

Class cancelled due to weather.
- ~~Midterm Exam. Closed book/notes/computer.~~

March 10 and March 12

No class; spring break.

March 17

Midterm Exam. Closed book/notes/computer.

- Solutions a , b , c

Grades:
90 - 100 : 18
80 - 89 : 11
70 - 79 : 5
60 - 69 : 8
below 60 : 2

March 19

- Review midterm.
- Matlab syntax and programming in Matlab
  - quick review
  - conditional statements and for-loops
- Homework 8.
  - Homework 8 solution.

March 24

- Midterm grades, etc.
- Programming in Matlab
  - for-loops, while-loops
  - tracing loops.

March 26

- Quiz (conditional statements, for-loops)
  - Solutions: a , b , c
- More on programming in Matlab
  - nested loops
  - tracing loops.
- Homework 9.
  - Solutions.

March 31

- User-written functions in Matlab.

April 2

- Quiz (mostly on loops, but a little on functions)
  - Solutions: a , b , c
- More on functions; polynomials; plotting.
  - Nested functions
  - Types of arguments
  - Polynomials
    - The `roots` Matlab function
  - Plotting functions
    - The `linspace` Matlab function
- Homework 10.
  - Solutions.

April 7

- Random number generation in Matlab and Monte Carlo applications.

  - Randomness in nature.
  - Probability distributions.
  - Statistical properties; mean, variance
  - Random number generation (Generation of simulated data)
  - Histograms.

- Homework 11. (Due April 14)

- Solutions.

April 9

- Discuss functions (HW10)
- Simple graphics in Matlab
- More on random number generation in Matlab and Monte Carlo applications.

April 14

- Quiz (mostly on functions)
  - Solutions: a , b , c
- Scaling and translating geometric regions.
- Homework 12. (Due April 16)
  - Solutions.

April 16

- Mathematical and computational models in science and engineering.
  - Numerical integration; the area under a curve.
  - Probability models: estimation using random samples.
  - Use of probability models to estimate the area under a curve.
- Homework 13. (Due April 21)
  - Solutions.
  - Let's do another one.

April 21

- Models in science.
  - Mathematical models.
  - Ordinary differential equations.
- Homework 14. (Due April 23)
  - Solutions.

April 23

- Review HW 13

- Verification and validation.
- Visualization and color maps.

April 28

- More on verification and validation.
- More on color maps; grayscale.
- Ethics.
- Homework 15 Due April 30
  - Solutions.
- Homework 16 Due May 5

April 30

- Quiz (mostly on color maps)
  - Solutions: a , b , c
- More on ethics; computer security, verification and validation.
- More on the logic of programming; review.
- Homework for review (Not to turn in.) Solutions
- More homework for review (Not to turn in.) Solutions

May 5

- Discuss Homework 15.
- Discuss Homework 16 (will not take up).
- General review (mostly in response to questions).
- Class evaluations.

May 7

- Snow day make-up (optional): further review; only questions from class.

May 12 (Tuesday) 10:30am-1:15pm

Final Exam. Closed book/notes/computer.

Cross-disciplinary Courses in COS

We believe that our proposed Computer Methods in Physics courses are unique in the University. Their subject matter is physics. Computers are tools and computer methods are the way these tools are used. To some extent, such ways are discipline-specific, and barring programs from teaching these deprives their students of skills in their majors.

Nevertheless, if some don't see it this way, that Computer Methods in Physics is actually a melding of two disciplines, then they have to accept that such cross-disciplinary courses can be taught by either discipline, as is customary in COS, as evidenced by the following list of existing courses:

BINF 354 - Foundations in Mathematical Biology
BINF 401 - Bioinformatics and Computational Biology I
BINF 402 - Bioinformatics and Computational Biology II
BINF 403 - Bioinformatics and Computational Biology Lab I
BINF 404 - Bioinformatics and Computational Biology Lab II
BINF 470 - Molecular Biophysics
BINF 550 - Introduction to Bioinformatics Database Design
BINF 634 - Bioinformatics Programming
BINF 641 - Biomolecular Modeling
BINF 690 - Numerical Methods for Bioinformatics
BINF 701 - Systems Biology
BINF 740 - Introduction to Biophysics
BINF 741 - Introduction to Computer Simulations of Biomolecules
BINF 751 - Biochemical and Cellular Systems Modeling

BIOL 580 - Computer Applications for the Life Sciences

CHEM 331 - Physical Chemistry I
CHEM 332 - Physical Chemistry II
CHEM 333 - Physical Chemistry for the Life Sciences I
CHEM 334 - Physical Chemistry for the Life Sciences II
CHEM 336 - Physical Chemistry Lab I
CHEM 337 - Physical Chemistry Lab II
CHEM 620 - Modern Instrumentation
CHEM 633 - Chemical Thermodynamics and Kinetics
CHEM 641 - Solid State Chemistry
CHEM 732 - Quantum Chemistry
CHEM 736 - Computational Quantum Mechanics
CHEM 833 - Physical Chemistry and Biochemistry

CHEM 446 - Bioinorganic Chemistry
CHEM 465 - Biochemistry Lab
CHEM 467 - The Chemistry of Enzyme-Catalyzed Reactions

CHEM 458 - Chemical Oceanography

CLIM 312 - Physical Climatology

CLIM 412 - Physical Oceanography
CLIM 710 - Introduction to Physical Climate System
CLIM 711 - Introduction to Atmospheric Dynamics
CLIM 712 - Physical and Dynamical Oceanography
CLIM 714 - Land-Climate Interactions
CLIM 715 - Numerical Methods for Climate Modeling

CDS 421 - Introduction to Computational Fluid Dynamics
CDS 461 - Molecular Dynamics and Monte Carlo Simulations

CSI 615 - Quantum Computation
CSI 654 - Data and Data Systems in the Physical Sciences
CSI 685 - Fundamentals of Materials Science
CSI 687 - Solid State Physics and Applications
CSI 715 - Quantum Complexity Theory
CSI 718 - Quantum Computer Realization
CSI 740 - Numerical Linear Algebra
CSI 742 - The Mathematics of the Finite Element Method
CSI 750 - Earth Systems and Global Changes
CSI 761 - N-Body Methods and Particle Simulations
CSI 764 - Computational Astrophysics
CSI 780 - Principles of Modeling and Simulation in Science
CSI 786 - Molecular Dynamics Modeling
CSI 788 - Simulation of Large-Scale Physical Systems
CSI 789 - Topics in Computational Physics
CSI 888 - Topics in Quantum Systems
CSI 986 - Advanced Topics in Large-Scale Physical Simulation

CSS 650 - Physics Methods for Analyzing Social Complexity

EVPP 210 - Environmental Biology: Molecules and Cells
EVPP 309 - Introduction to Oceanography

FRSC 440 - Advanced Forensic Chemistry
FRSC 512 - Physical Evidence Analysis
FRSC 540 - Forensic Chemistry

GGS 102 - Physical Geography
GGS 312 - Physical Climatology
GGS 321 - Biogeography
GGS 456 - Introduction to Atmospheric Radiation
GGS 671 - Algorithms and Modeling in GIS
GGS 721 - Biogeography
GGS 756 - Physical Principles of Remote Sensing

GEOL 316 - Computers in Geology

GEOL 412 - Physical Oceanography
GEOL 417 - Geophysics

GEOL 458 - Chemical Oceanography

NANO 500 - Introduction to Nanomaterials and Interactions
NANO 610 - Nanoelectronics
NANO 620 - Computational Modeling in Nanoscience

NEUR 734 - Computational Neurobiology
NEUR 735 - Computational Neuroscience Systems
NEUR 752 - Modern Instrumentation in Neuroscience
NEUR 851 - Advanced Computation and Brain Dynamics

Note, for example, that CSS 650 - Physics Methods for Analyzing Social Complexity is taught in CDS, and several numerical methods courses are taught in the program employing such methods.

Quite obviously, the subject matter of all such courses is not the methods used to study their true subjects.

Physics Courses and Concentrations at Institutions with Computational Programs

Institution	Program	Physics Courses	Physics Concentration
Boston U	Computational Science	Introduction to Computational Physics Advanced Scientific Computing in Physics	Interdisciplinary Option
Cal Tech	Applied and Computational Mathematics	Astrophysics and Cosmology with Open Data Computational Physics Laboratory I, II, III Quantum Computation	
Central Washington	Computational Science	Computational Physics Advanced Computational Physics	
Chapman U	Computational Science		Physics and Computational Science
Clark U	Computational Science	Computer Simulation Laboratory Advanced Computer Simulation Laboratory	Computational Science
Colorado State	Applied and Computational Mathematics		Applied Physics
Cornell	Computational Science and Engineering	Computational Physics	Complementary
Duke	Computational Science, Engineering, and Medicine	Computational Physics	Biophysics
Florida State	Applied and Computational Mathematics Scientific Computing	Computational Physics Laboratory	Astrophysics Physical Science FSU-Teach
Georgia State	Scientific Computing		Applied Physics Astronomy Pre-Medicine Biophysics Geology Computer Science Education
Georgia Tech	Computational Science and Engineering	Computational Physics Quantun Information and Quantum Computing	Applied Physics Astrophysics Business
Indiana U, Bloomington	Scientific Computing	Computing Applications in Physics I, II	Applied Physics Medical Physics
Johns Hopkins U	Applied and Computational Mathematics	Introduction to Practical Data Science: Beautiful Data Practical Scientific Analysis of Big Data Graphics Processor Programming in CUDA Modeling Matter Across Multiple Length & Time Scales	
Louisiana Tech	Computational Analysis and Modeling	Computational Methods in Physics Modeling and Simulation I,II	Interdisciplinary Options
LSU	Computation and Technology	Computational Science Computational Physics Monte Carlo Simulation of Radiation Transport	Astronomy Secondary Education Second Discipline
Michigan Tech U	Computational Science and Engineering	Computational Methods in Physics Computer Simulation in Physics	Applied Physics Secondary Education
Mississippi State	Computational Engineering and High Performance Computing	Computational Physics	Applied Physics
MIT	Computation for Design and Optimization	Classical Mechanics: A Computational Approach Quantum Computation	Flexible Option
NC State	Computational Science and Engineering Center for Research in Scientific Computation	Introduction to Scientific Computing Instrumental and Data Analysis for Physics Computational Physics	
Northwestern	Engineering and Applied Mathematics	Statistical Methods for Physicists and Astronomers	Integrated Science
NYU	Mathematics and Computer Science	Computational Physics Quantum Information and Quantum Computing	Physics and Engineering

Institution	Program	Physics Courses	Physics Concentration
Ohio U	Computational Science	Computer Simulation Methods in Physics	Applied Physics Astrophysics Meteorology
Old Dominion	Modeling and Simulation Computational and Applied Mathematics	Introductory Computational Physics	Research Professional Education Physics and Electrical Engineering Physics and Business
Penn State	Computational Science Center for Computational Mathematics and Applications		General Physics Computational Physics Electronics Medical Physics Materials Science Nanotechnology
Princeton	Applied and Computational Mathematics Institute for Computational Science and Engineering	Computational Physics Seminar	Engineering Physics Biophysics Physics and Finance Integrated Science
Purdue U	Computational Science and Engineering Center for Computational and Applied Mathematics	Quantum Computing Computational (Bio)molecular Physic Computational Physics	Applied Physics Science Education
Rice	Computational Science and Engineering Computational and Applied Mathematics	Computational Physics Computational Eletrodynamics and Nanophotonics	General Physics Applied Physics Biological Physics Computational Physics
RPI	Computational Science and Engineering	Computational Physics	Applied Physics Computational Physics
San Diego State	Computational Science	Introduction to Computational Physics Computational Physics	Chemical Physics Teaching
Southern Methodist	Center for Scientific Computation	Computational Physics	Biophysical Sciences
Stanford	Mathematical and Computational Science Institute for Computational and Mathematical Engineering	Practical Computing for Scientists Computational Physics Computational Cosmology and Astrophysics	Applied Physics Astrophysics Biophysics and Medical Physics Geophysics Theoretical Physics
SUNY Brockport	Computational Science		Secondary Teaching
SUNY Stony Brook	Computational Applied Mathematics	Computation for Physics and Astronomy	Optics
Syracuse U	Computational Science	Science and Computers I, II	Biological and Medical Physics
Texas A&M	Institute for Scientific Computation	Computational Physicomputational Physics	
U Arizona	Computational Science and Numerical Analysis	Introduction to Scientific Computing Computational Physics	Science Education
UC Berkeley	Computational Science and Engineering	Introduction to Computational Techniques in Physics Computational Nanoscience	
UC Davis	Computational Science and Engineering	Computational Laboratory in Physics Computational Methods of Mathematical Physics Introduction to Computer-Based Experiments in Physics Computational Physics	Applied Physics
UC San Diego	Computational Science, Mathematics, and Engineering Center for Computational Mathematics		Biophysics
UC Santa Barbra	Computational Science and Engineering		
UCLA	Computational and Applied Mathematics	Numerical Computational Physics Numerical Analysis Techniques and Particle Simulations Computational Physics and Astronomy Laboratory	Biophysics Astrophysics

Institution	Program	Physics Courses	Physics Concentration
U Chicago	Computational Mathematics	Computational Physics	Astrophysics
U Delaware	Mathematical Computation Numerical Analysis and Scientific Computing	Computational Methods of Physics Quantum Computation	Astronomy Astrophysics Geophysics
U Houston	Computational Sciences Initiative	Computational Physics	
U Illinois, Chicago	Applied Mathematics and Computational Science	Computational and Mathematical Methods for the Physical Sciences	Instructional Leadership
U Illinois, Urbana-Champaign	Computational Science and Engineering	An Introduction to Computing in Physics I, II	Science and Letters Physics Specialized Physics Physics Teaching Engineering Physics
U Iowa	Applied Mathematical and Computational Sciences	Computational Physics	Applied Physics Physics and Engineering Medicine Science Teaching
U Kentucky	Applied and Computational Mathematics	Computational Phy Lab Computational Physics	
U Maryland	Applied Mathematics and Scientific Computation Scientific Computation Center for Scientific Computation and Mathematical Modeling	Computational Physics	Secondary Education
U Mass, Dartmouth	Computational Mathematics		Astronomy Astrophysics
U Mass, Lowell	Computational Mathematics	Physics with Computers I Numerical Methods of Radiological Sciences	Applied Physics Radiological Science Radiological Health Physics Optics
U Michigan	Lab for Scientific Computation	Introduction to Computational Physics Computational Science and the Rise of the Fourth Paradigm	Interdisciplinary Physics Teacher Certification Applied Physics
U Michigan, Dearborn	Applied and Computational Mathematics	Computational Physics	
U Minnesota	Scientific Computation	Computational Methods in the Physical Sciences	Professional Physics Engineering Physics Biological Physics Physics for Teaching Computational Physics
U Minnesota, Duluth	Applied and Computational Mathematics	Quantum Computation Computational Methods in Physics	Secondary Teacher Education Applied Physics
U Southern Mississippi	Computational Science		
U Tennessee, Knoxville	Computational Science Joint Institute for Computational Sciences Applied and Computational Mathematics		Academic Astronomy General
UT Austin	Computational Science, Engineering, and Mathematics	Introduction to Computational Physics	Computation Radiation Physics Space Sciences Teaching Biophysics
U Utah	Computational Engineering and Science Scientific Computing and Imaging Institute Computational Bioimaging Certificate School of Computing	Introduction to the Tools of Scientific Computing Introduction to Computing in Physics Computational Physics	Professional Physics Applied Physics Biomedical Physics Physics Teaching
U Washington, Seattle	Applied and Computational Mathematical Sciences	Introduction to Computational Physics Application of Computers to Physical Measurement	Applied Biological Comprehensive Teaching Prep
Western Michigan U	Applied and Computational Mathematics		Secondary Education Geophysics