COS Curriculum Committee Course Proposal

1. COURSE NUMBER AND TITLE:

PHYS 150: Computing for Physics and Engineering I

Course Prerequisites: None

Course Corequisites: MATH 113

Catalog Description:

An introduction to computing in physics and engineering. Covers the basics of writing and testing programs using a high-level procedural programming language. Programming applications include simulation of dynamical systems, statistical analysis, and visualization.

Fulfills Mason Core requirement in information technology (all).

Corequisite(s): MATH 113.

Hours of Lecture or Seminar per week: 3

2. COURSE JUSTIFICATION:

Course Objectives:

- To use a programming language to numerically solve physics and engineering problems encountered in first-year coursework.
- To use a programming language to analyze and visualize data encountered in physics and engineering coursework.
- To have experience using packages for one or more programming languages to solve advanced programming and data analysis problems that will be encountered in physics and engineering coursework.
- To develop proficiency with programming syntax in a high-level procedural programming language.
- To develop proficiency in troubleshooting, debugging, validation, and verification of computer programs.
- To develop and analyze the results of numerical experiments of physical systems.
- To become proficient in core IT learning outcomes and understand and be able to analyze ethical problems related to computing. The outcomes covered include the five items listed at http://masoncore.gmu.edu/general-education-at-mason-2/information-technology-1/.

Course Necessity:

The necessity of this course was identified by a committee that considered the requirements of physics and astronomy majors related to computation. The objectives and topics covered by the proposed course are based on feedback from faculty members in the department of physics and astronomy and the engineering school. The proposed course has been discussed with engineering faculty and they have expressed interest in including it as an option for their students.

This course is a first step in a plan for integration of computation into the physics and astronomy curriculum. Many of the homework assignments and examples in the proposed course will reinforce concepts covered in introductory physics courses. This course will be a required gateway course for physics and astronomy majors, and students will be expected to employ the skills introduced in this course in subsequent physics and astronomy laboratory, computational, and theory courses.

In the near future we plan on proposing a follow-on course, Computing for Physics and Engineering II, that will in part serve to prepare physics, astronomy, and engineering majors for work on independent research projects after their second year of coursework.

Course Relationship to Existing Programs:

The proposed course provides basic content for students who plan to pursue a degree in astronomy, physics, or engineering.

Course Relationship to Existing Courses:

The primary objective of this course is to introduce physics and engineering students to computing techniques and applications that can be used in their subsequent coursework. The primary motivation of a new course is the desire to integrate computation into the curriculum of undergraduate physics and astronomy majors in a uniform way that can be built upon in subsequent coursework.

A number of possible alternatives to this course were considered, including CDS 101, CS 112, and CDS 130. CDS 101 has not been offered for three years, and it was designed to be an elective for non-science majors. In the past, physics majors have had the option of taking CS 112 as an elective. Based on our experience and student feedback, this course is targeted at computer science majors; very few physics and engineering applications are considered. While CDS 130 also introduces programming in MATLAB, its coverage of applications is more general and the examples and applications covered are insufficient for physics and engineering students. (The primary overlap between the proposed course and CDS 130 are the topics covered in weeks 2 and 3 of the proposed course). We have found that CDS 130 is not sufficiently tailored to physics and engineering students and as a result students who complete this course are not adequately prepared to apply computational problem solving techniques to physics and engineering problems.

3. APPROVAL HISTORY:

None

4. **SCHEDULING AND PROPOSED INSTRUCTORS**:

Semester of Initial Offering:

Fall 2016

Proposed Instructors:

Camelli, Kan, Lohner, Marzougui, Rubin, Sheng, Weigel, Yang, Zhang

5. **TENTATIVE SYLLABUS**: See attached.

Syllabus for PHYS 150

Computing for Physics and Engineering I

Contact Information

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

Course Objectives

- To use a programming language to numerically solve physics and engineering problems encountered in first-year coursework.
- To use a programming language to analyze and visualize data encountered in physics and engineering coursework.
- To have experience using packages for one or more programming languages to solve advanced programming and data analysis problems that will be encountered in physics and engineering coursework.
- To develop proficiency with programming syntax in a high-level procedural programming language.
- To develop proficiency in troubleshooting, debugging, validation, and verification of computer programs.
- To develop and analyze the results of numerical experiments of physical systems.
- To become proficient in core IT learning outcomes and understand and be able to analyze ethical problems related to computing. The outcomes covered include the five items list at http://masoncore.gmu.edu/general-education-at-mason-2/information-technology-1/. Information about how these outcomes are addressed are covered in the last section of this syllabus.

Schedule

Week 1: Overview, introduction, and software installation
Week 2: Assignment, control statements, and arrays
Week 3: Iteration and IT applications
Week 4: Functions
Week 5: Introduction to numerical solutions of rate-of-change problems
Week 6: Solving kinematic equations
Week 7: Solving dynamical system equations

Week 8: File Input and Output - Fundamentals
Week 9: File Input and Output - Applications to lab data and data encountered on web
Week 10: Statistical Analysis - Computing test statistics and hypothesis testing
Week 11: Statistical Analysis - Solving overdetermined systems of equations
Week 12: Visualization - Presenting the results of experiments
Week 13: Computing ethics
Week 14: Using packages and project presentations

Textbooks

- Matlab, Third Edition: A Practical Introduction to Programming and Problem Solving by Attaway, 2013 (Required)
- Computational Physics 2nd Edition by Giordano and Nakanishi, 2005 (Required)
- Computational Physics using MATLAB an on-line free document by Nakanishi that uses MATLAB for the example problems covered in Computational Physics 2nd Edition by Giordano and Nakanishi, 2005. See also http://www.physics.purdue.edu/~hisao/book/ for examples in Fortran and C.

Software

During the first week, students will download and install a preconfigured virtual machine containing most of the software that they will need to use in this course. This virtual machine will run Linux, and students will be able to write and test their programs by launching the virtual machine in Windows, OS-X, and Linux. Students will only need to purchase a license for MATLAB ($49 Student Edition).

The virtual machine will come with an up-to-date Linux distribution with git, Octave, Python, and ParaView pre-installed.

Grading

- Exams: 40% - One midterm and one final, equally weighted. You will be given sample exams to practice from. The exam will contain a hand-written part and a part that requires the use of a computer.
- Homework: 40% - Usually one assignment per week. Challenging extra credit problems will be given on approximately 1/2 of the homework assignments. The lowest homework grade is dropped. If you miss a homework, you may use the extra credit assignments to boost your homework score. As part of each solution to a problem, you are to identify and cite resources used to solve the problem. Examples for how to do this will be given on the first two homework assignments.
- Project: 20% - The project will be assigned near the middle of the semester. You will turn in parts of the project as a part of homework assignments and will be required to give short oral updates. The first assignment associated with the project is a project proposal.

Letter Grades

- > 97: A+
- 93 to 96.9...: A
- 90 to 92.9...: A-
- 87 to 89.9...: B+
- 83 to 86.9...: B
- 80 to 82.9...: B-
- 77 to 79.9...: C+
- 73 to 76.9...: C
- 70 to 72.9...: C-
- 60 to 69.9...: D
- < 60: F

Collaboration Policy

Turning in a write-up or code that is similar to another student's will be treated as an honor code violation. The best way to avoid an honor code violation while seeking help from a classmate is to have them look at your work when you are stuck and then suggest modifications to what you have done (rather than you looking at their solution); always start your homework prior to having any discussion with other students. Indicate the name of any student who helped you, and how they helped you, on your homework assignment.

Referencing Policy

It is quite unlikely that any homework problem will have a solution available online, and you are encouraged to use other resources to help you with parts of a problem.

If you used a website or a book while doing your homework, reference it. (This is a good habit to have when you do any programming or writing - quite often I will come back to a project and use the references to better understand what I did.) In addition, you should reference anything used as a matter of principle.

Academic Integrity

From [http://ctfe.gmu.edu/teaching/designing-your-syllabus/]:

The integrity of the University community is affected by the individual choices made by each of us. Mason has an Honor Code with clear guidelines regarding academic integrity. Three fundamental and rather simple principles to follow at all times are that: (1) all work submitted be your own; (2) when using the work or ideas of others, including fellow students, give full credit through accurate citations; and (3) if you are uncertain about the ground rules on a particular assignment, ask for clarification. No grade is important enough to justify academic misconduct. Plagiarism means using the exact words, opinions, or factual information from another person without giving the person credit. Writers give credit through accepted documentation styles, such as parenthetical citation, footnotes, or endnotes. Paraphrased material must also be cited, using MLA or APA format. A simple listing of books or articles is not sufficient. Plagiarism is the equivalent of intellectual robbery and cannot be tolerated in the academic setting. If you have any doubts about what constitutes plagiarism, please see me.

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 me to discuss your accommodation needs.

University Policies

See http://universitypolicy.gmu.edu/

Student Support Services

See http://ctfe.gmu.edu/teaching/student-support-resources-on-campus/

IT with Ethics

This course was developed to meet the requirements of Mason's General Education with IT Ethics. Details for how the five outcomes for this requirement are given in this section.

Outcome 1: Students will be able to use technology to locate, access, evaluate, and use information, and appropriately cite resources from digital/electronic media.

This objective is covered by course objective "To have experience using packages for one or more programming languages to solve advanced programming and data analysis problems that will be encountered in physics and engineering coursework.". This objective is met in Week 14 and 15 "Using packages and project presentations". In addition, the syllabus contains a statement on citing code that was used to solve homework problems; all homework assignments will include a section where the student cites or describes resources that were used to solve the problem.

Outcome 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.

One of the core IT concepts is writing programs in a high-level procedural programming language. The first three weeks of the semester covers this topic. In addition, students will use a virtual machine with Linux and other open source science packages.

Outcome 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.

Covered in the lecture, activity, and follow-up homework on common morality given at the end of this document.

Outcome 4: Students will demonstrate the ability to communicate, create, and collaborate effectively using state-of-the-art information technologies in multiple modalities.

This outcome is covered by the required project and the fact that students will be required to turn in their homework assignments and manage their group projects using a Git repository hosted by Bitbucket. Also covered by their use of a virtual machine.

Outcome 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.

Covered by a programming assignment in Week 3, which covers iteration, in which they are asked to develop programs that guess passwords and evaluate the amount of time that would be required on average. A follow-up short tutorial will cover modern methods of preventing such "brute-force" attacks and at least one topic on safety when using Wi-Fi networks and HTTP instead of HTTPS.

The following is an assignment that will be given during week 13, which covers computing ethics.

Common Morality

Instructor notes: Most of sections 1-5 is based on Gert, 1999 [1]. For clarity of presentation, not all direct quotes are cited. During the first class period, a brief overview is given on items 1-5 below by the instructor. Students may be asked to read Gert, 1999 [1] and be prepared to answer basic questions about it on a quiz before items 1-5 are covered by the instructor. Then the students work in groups on the activity in section 6. The students turn in their activity notes and the instructor discusses them in a follow-up class. After the follow-up class, students are given the assignment in section 7.

1. Common morality and computing

Bernard Gert [1]

"... common morality can be helpful in clarifying the discussion of moral issues that arise in computing."

2. Key Points in [1]

- There is no agreement on moral matters.
- However, most would agree on a common set of moral principles.
- This common set can provide a framework for addressing moral questions.
- This framework allows disagreement to managed in a productive way.

3. The Justified Moral Rules

Ten rules that can be supported by all impartial rational persons who used only rationally required beliefs.

The Justified Moral Rules

1. Do not kill.
2. Do not cause pain.

3. Do not disable.
4. Do not deprive of freedom.
5. Do not deprive of pleasure.
6. Do not deceive.
7. Keep your promises.
8. Do not cheat.
9. Obey the law.
10. Do your duty.

The rules are not absolute; they all have justified exceptions, and most moral problems involve determining which exceptions are justified.

4. Impartial Rational Persons

Attitude of all impartial rational persons toward the moral rules: Everyone is always to obey a moral rule except when a fully informed rational person can publicly allow violating it. If all fully informed rational persons publicly allow the violation, it is strongly justified, If fully informed rational persons disagree about whether to publicly allow the violation, it is weakly justified.

5. Probing Questions

Gert claims that "... all morally relevant features that we have discovered thus far are answers to the following questions."

1. What moral rules would be violated?
2. What harms would (a) be avoided (not caused), (b) prevented, and (c) caused? (This means foreseeable harms and includes the probabilities as well as kind and extent.)*
3. What are the relevant beliefs and desires of the people toward whom the rule is being violated?
4. Does one have a relationship with the person(s) toward whom the rule is being violated such that one sometimes has a duty to violate moral rules with regard to the person(s) without their consent?
5. What benefits would be caused? (This means foreseeable benefits and also includes probabilities, as well as kind and extent).
6. Is an unjustified or weakly justified violation of a moral rule being prevented?
7. Is an unjustified or weakly justified violation of a moral rule being punished?

8. Are there any alternative actions that would be preferable?
9. Is the violation being done intentionally or only knowingly?
10. Is it in emergency situation that no person is likely to plan to be in?

When considering the harms being avoided (not caused), prevented, and caused, and the benefits being promoted, one must also consider their seriousness, duration, and probability.

Anyone who claims to be acting or judging as an impartial rational person who holds that one of the two violations be publicly allowed must hold that the other also be publicly allowed.

* The distinction between avoid and prevent is the same as in this sentence: "I avoided the traffic jam by taking an alternate route. I prevented the traffic jam by building additional lanes." Avoidance in this sense means "going around". Prevention involves "taking pre-emptive action" so that avoidance is not necessary. Also, from [2]:

- Avoid = stay clear from; keep away from; keep out of the way of someone or something; refrain from
- Prevent = keep from happening or arising; stop (someone, something) from doing (something)

6. Activity

A follow-up homework will be based on this in-class activity.

For each of the three cases given below, answer the question given in section 5 and then provide a statement of if an impartial rational person would conclude that the action was moral. If you conclude that an impartial rational person would allow a violation of a justified moral rule for the case, is the violation strongly or weakly justified?

At the end of class, email the document to your instructor.

6.1. Case I

From [3]

In determining requirements for an information system to be used in an employment agency, the client explains that, when displaying applicants whose qualifications appear to match those required for a particular job, the names of white applicants are to be displayed ahead of those of nonwhite applicants, and names of male applicants are to be displayed ahead of those of female applicants. You agree to the requirements and deliver the information system to the agency.

6.2. Case II

The software that is used to encrypt messages relies on mathematical equations that take a very long time to solve.

While working on your PhD thesis, you make a discovery of a new equation. Later you realize that your discovery would allow messages to be easily decrypted. You publish your discovery.

6.3. Case III

You click a license agreement for software that states that it may only be used by you on one computer.

You have not used the software and don't plan on using it. You allow a friend to install the software on his computer.

You install the software on another computer that you now use exclusively. In order to do this, you needed to install a special program found on a hacker website.

7. Assignment

For each of the four cases given below, answer the questions given in section 5. Exclude questions 4 and 7. For each answer, provide a justification.

After the list of questions, conclude with a statement of if an impartial rational person would conclude that the action was moral. If you conclude that an impartial rational person would allow a violation for the case, state whether the violation strongly or weakly justified.

You will be graded on the following criteria: (1) whether you followed the instructions, (2) if is there evidence that thought was put into your answers, and (3) the quality and depth of your reasoning.

You may work in at most a group of three. At the end of the document, include the statement "The following members of this group certify that this was a group effort and all group members should receive the same score" along with a list of the names of the group members.

7.1. Case I

From [4]

In determining requirements for an information system to be used in an employment agency, the client explains that, when displaying applicants whose qualifications appear to match those required for a particular job, the names of white applicants are to be displayed ahead of those of nonwhite applicants, and names of male applicants are to be displayed ahead of those of female applicants.
Action: You agree to the requirements and deliver the information system to the agency.

7.2. Case II

The software that is used to encrypt messages relies on mathematical equations that take a very long time to solve.

While working on your PhD thesis, you make a discovery of a new equation. Later you realize that your discovery would allow messages to be be easily decrypted.

Action: You publish your discovery.

7.3. Case III

You click a license agreement for software that states that it may only be used by you on one computer.

Action 1: You have not used the software and don't plan on using it. You allow a friend to install the software on his computer.

Action 2: You install the software on another computer that you now use exclusively. In order to do this, you needed to install a special program found on a hacker website. The special software prevents the installer program from checking with a database that tracks the number of computers that it was installed on.

7.4. Case IV

An instructor posts a solution to a question on a homework assignment after the original due date of the assignment. He forgot that he gave an extension to the assignment due date when he posted the solution. In the solution, he made an error (typo).

Action: A student turns in the assignment with the same error (which is unlikely to have occurred by chance).

GEORGE MASON UNIVERSITY

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) [ ] Credits [ ] Repeat Status [ ] Schedule Type [ ] Prereq/coreq [ ] Restrictions [ ] Grade Mode [ ] Other: ______

Course Level: [x] Undergraduate [ ] Graduate

College/School: College of Science
Department: Physics and Astronomy
Submitted by: Robert Weigel
Ext: 3-1361
Email: rweigel@gmu.edu

Subject Code: PHYS **Number:** 150
(Do not list multiple codes or numbers. Each course proposal must have a separate form.)

Effective Term: [x] Fall [ ] Spring [ ] Summer Year 2016

Title:
Current
Banner (30 characters max w/ spaces)
New: Computing for Physics and Engineering 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):

Corequisite(s): MATH 113

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)
An introduction to computing in physics and engineering. Covers the basics of writing and testing programs using a high-level procedural programming language. Programming applications include simulation of dynamical systems, statistical analysis, and visualization.	

Indicate number of contact hours: Hours of Lecture or Seminar per week: 3 Hours of Lab or Studio: 0
When Offered: (check all that apply) [x] Fall [x] 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 ______

Mason Core Course Approval Form (05/15)

GEORGE MASON UNIVERSITY

College/School:	College of Science	**Department:**	Physics and Astronomy		
Submitted by:	Robert Weigel	**Ext:** 3-1361	**Email:** rweigel@gmu.edu	**Date:**	2-17-2016

[x] **NEW** [ ] **EXISTING** [ ] **MODIFIED**
[ ] **ALREADY APPROVED FOR ANOTHER CATEGORY?** [ ] **LIST CATEGORY**

Subject Code: PHYS **Number:** 150 **Credit Hours:** 3 **Title:** Computing for Physics and Engineering I

Mason Core Category: Information Technology: <u>ALL</u> ~~WITHOUT ETHICS ETHICS ONLY~~

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.

PLEASE PROVIDE THE FOLLOWING INFORMATION

Submissions should be sent in hard copy to Marcy Glover, MSN: 1D9 or as one, combined, complete, electronic file with all signatures from both the department chair/director and appropriate dean. Forms missing signatures will be returned to the applicable associate dean's office for verification.

(TIPS: • Student Learning Outcomes stated in the proposal <u>must</u> be clearly demonstrated in the syllabus; • it is helpful to the committee to know how student learning will be evaluated with regard to the learning outcomes; use this space to elaborate on any related aspects of the course that may not be easily discernible from the syllabus; • please include information on the requirements for projects/papers if they are used to demonstrate student learning outcomes.)

1. SYLLABUS: Please see the Center for Teaching and Faculty Excellence website (http://ctfe.gmu.edu/teaching/designing-your-syllabus/) for guidance on syllabus construction and standard elements. All syllabi must include statements about students with disabilities and the Office of Disability Services office, as well as Academic Integrity, oai.gmu.edu.
2. Which learning outcomes does this course address? Please demonstrate where in the syllabus this is reflected. **See last section of syllabus.**
3. What assignments will you give that will allow students to demonstrate their competence for each outcome? **See last section of syllabus.**

Approval Signatures

Department Approval Date College/School Approval Date

Provost Date

For Provost Office's Use Only: A/R: ________ NOT: ________ RO: ________ WP: ________ CAT: ________