هيئة تقويم التعليم
Education Evaluation Commission
المركز الوطني للتقويم والاعتماد الأكاديمي
National Center for Academic Accreditation and Evaluation

# COURSE SPECIFICATIONS (CS)

## Computational Physics

**PHYS 400**

June 2018

# Course Specifications

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|---|---|
| Institution: **King Saud University** | Date: 03.12.2017 |
| College/Department: **College of Science- Department of Physics and Astronomy** | |

A. Course Identification and General Information

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| 1. Course title and code: **Computational Physics**, **PHYS 400** |
| 2. Credit hours: **2(1+0+2)** |
| 3. Program(s) in which the course is offered.<br>(If general elective available in many programs indicate this rather than list programs)<br>**Physics BSc degree** |
| 4. Name of faculty member responsible for the course |
| 5. Level/year at which this course is offered<br>**7th term/ Fourth year** |
| 6. Pre-requisites for this course (if any)<br>**PHYS 301** |
| 7. Co-requisites for this course (if any)<br>**None** |
| 8. Location if not on main campus<br>**Main Campus** |
| 9. Mode of Instruction (mark all that apply) |

| Mode | Mark | | Percentage |
|---|---|---|---|
| a. traditional classroom | X | What percentage? | **50%** |
| b. blended (traditional and online) | | What percentage? | |
| c. e-learning | | What percentage? | |
| d. correspondence | | What percentage? | |
| f. other: practical | X | What percentage? | **50%** |

Comments:

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B Objectives

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| 1. What is the main purpose for this course?<br>✓ Deepening the understanding of fundamental principles of physics and of how it can be used to explain and predict physical phenomena.<br>✓ Full knowledge of mathematical techniques and the ability to use them in quantitative prediction, modeling physical phenomena and solving complex physical problems.<br>✓ Knowledge of computational physics and its different tools which can be used in the different physics fields.<br>✓ The ability to use scientific programming for processing and analyzing data, solving mathematical equations numerically and simulating experiments. |
| 2. Briefly describe any plans for developing and improving the course that are being implemented. (e.g. increased use of IT or web based reference material, changes in content as a result of new research in the field)<br>a) The course material is available on the lecturer webpage.<br>b) Students are asked to find and download standard codes from internet and modify them to solve homework.<br>c) Use of recent examples for applying computational methods.<br>d) Use of scientific programming during the hands-on sessions. |

C. Course Description (Note: General description in the form used in Bulletin or handbook)

Course Description:
1. Introduction:The need for computers in science, What is computational physics?, Operating systems and programming languages.
2. Interpolation: Lagrange interpolation, Neville's algorithm, Linear interpolation, Polynomial interpolation, Cubic spline, Rational function interpolation
3. Numerical differentiation: Forward difference, Central difference and higher order methods, Higher order derivatives
4. Numerical Integration: Rectangular method, Trapezoid method, Simpson method
5. Solution of nonlinear equations: Bisection method, Newton's method, Method of secants, Brute force method
6. Differential equations: Euler method, Numerical errors and instabilities, Runge-Kutta method
7. Monte-Carlo methods: Random number generators, Distribution functions, Acceptance and rejection method, Inversion method

Practical Part:
Introduction to Linux
Scientific programming

1. Topics to be Covered

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|---|---|---|
| List of Topics | No. of Weeks | Contact hours |
| **1. Introduction**<br>○ The need for computers in science.<br>○ What is computational physics?<br>○ Operating systems and programming languages. | 1 | 1 |
| **2. Interpolation**<br>○ Lagrange interpolation<br>○ Neville's algorithm<br>○ Linear interpolation<br>○ Polynomial interpolation<br>○ Cubic spline<br>○ Rational function interpolation | 2 | 2 |
| **3. Numerical differentiation**<br>○ Forward difference<br>○ Central difference and higher order methods<br>○ Higher order derivatives | 2 | 2 |
| **4. Numerical Integration**<br>○ Rectangular method<br>○ Trapezoid method<br>○ Simpson method | 2 | 2 |
| **5. Solution of nonlinear equations**<br>○ Bisection method<br>○ Newton's method<br>○ Method of secants<br>○ Brute force method | 2 | 2 |
| **6. Differential equations**<br>○ Euler method<br>○ Numerical errors and instabilities<br>○ Runge-Kutta method | 3 | 3 |
| **7. Monte-Carlo methods**<br>○ Random number generators<br>○ Distribution functions<br>○ Acceptance and rejection method<br>○ Inversion method | 3 | 3 |
| **Practical Part:** | | |
| **Introduction to Linux** | - | 2 |
| **Scientific programming** | - | 28 |

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| 2. Course components (total contact hours and credits per semester): |

| | Lecture | Tutorial | Laboratory or Studio | Practical | Other: | Total |
|---|---|---|---|---|---|---|
| Contact Hours | 15 | | | 30 | | 45 |
| Credit | 15 | | | 15 | | 30 |

3. Additional private study/learning hours expected for students per week.
At least 4 hours per week

4. Course Learning Outcomes in NQF Domains of Learning and Alignment with Assessment Methods and Teaching Strategy

On the table below are the five NQF Learning Domains, numbered in the left column.

**First**, insert the suitable and measurable course learning outcomes required in the appropriate learning domains (see suggestions below the table). **Second**, insert supporting teaching strategies that fit and align with the assessment methods and intended learning outcomes. **Third**, insert appropriate assessment methods that accurately measure and evaluate the learning outcome. Each course learning outcomes, assessment method, and teaching strategy ought to reasonably fit and flow together as an integrated learning and teaching process. (Courses are not required to include learning outcomes from each domain.)

| Code # | NQF Learning Domains And Course Learning Outcomes | Course Teaching Strategies | Course Assessment Methods |
|---|---|---|---|
| **1.0** | **Knowledge** | | |
| 1.1 | List numerical methods used to solve physical problems. | Lectures | Homework, take home exam and final exam. |
| 1.2 | Write codes using high level languages for scientific programming to process and analyze data, solve mathematical problems, and simulate experiments. | Hands-on sessions | Homework (codes to be developed by the students) and practical exam. |
| **2.0** | **Cognitive Skills** | | |
| 2.1 | Calculate and evaluate the results of physical phenomena using numerical methods. | Lectures and hands-on sessions | Homework and take-home exams. |
| 2.2 | Design experimental setups and predict the results. | Lectures and hands-on sessions | Homework and take-home exams. |
| **3.0** | **Interpersonal Skills & Responsibility** | | |

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| 3.1 | Show the ability to work in a team. | Encourage students to form groups to achieve specific goals. | Group homework and shared projects. |
| 3.2 | Show the ability to work independently | Small individual projects | Homework |
| **4.0** | **Communication, Information Technology, Numerical** | | |
| 4.1 | Calculating and interpreting the results of physics problems. | Encouraging students to participate during lectures and hands-on sessions. | Quizzes and homework. |
| 4.2 | Evaluate the results of physical phenomena using numerical methods. | Discussions during lectures and hands-on sessions | Homework and take-home exams. |
| **5.0** | **Psychomotor** | | |
| 5.1 | **not applicable** | **not applicable** | **not applicable** |

| 6. Schedule of Assessment Tasks for Students During the Semester | | | |
|---|---|---|---|
| | Assessment task (e.g. essay, test, group project, examination, speech, oral presentation, etc.) | Week Due | Proportion of Total Assessment |
| 1 | Homework (one for each chapter) | End of each week starting from week 8 | 10% |
| 2 | Take-home exam (2) | 6-12 | 10% |
| 3 | Practical exam | 14 | 20% |
| 4 | Quizzes | weekly | 10% |
| 5 | Attendance and Participation | | 10% |
| 6 | Final exam | 16 | 40% |

D. Student Academic Counseling and Support

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| 1. Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice. (include amount of time teaching staff are expected to be available each week) |

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| Office hours: 10 h/week |

E Learning Resources

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| 1. List Required Textbooks<br>- **"Computational Physics", Nicholas J. Giordano, Hisao Nakanishi, Addison-Wesley, 2006**<br>- **"Introductory Computational Physics", Andi Klein and Alexander Godunov, Cambridge University Press, 2010.** |
| 2. List Essential References Materials (Journals, Reports, etc.)<br>**"Computational Physics", Richard Fitzpatrick, lecture notes, University of Texas at Austin.** |
| 3. List Recommended Textbooks and Reference Material (Journals, Reports, etc) |
| 4. List Electronic Materials, Web Sites, Facebook, Twitter, etc.<br>http://farside.ph.utexas.edu/teaching/329/lectures/lectures.html<br>http://www.courses.physics.helsinki.fi/fys/cprog/ |
| 5. Other learning material such as computer-based programs/CD, professional standards or regulations and software. |

F. Facilities Required

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| Indicate requirements for the course including size of classrooms and laboratories (i.e. number of seats in classrooms and laboratories, extent of computer access etc.) |
| 1. Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.)<br>• Computer lab for 20 students<br>• Lecture room for 20 students |
| 2. Computing resources (AV, data show, Smart Board, software, etc.)<br>• Linux OS<br>• Fortran, C/C++ compilers. |
| 3. Other resources (specify, e.g. if specific laboratory equipment is required, list requirements or attach list) |

G Course Evaluation and Improvement Processes

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| 1 Strategies for Obtaining Student Feedback on Effectiveness of Teaching<br>• One of the most valuable methods by which students and faculty may collaboratively work to improve instruction in any educational endeavor is through formalized student feedback, namely **course evaluations**. |

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| • Asking question before, during and after each lecture.<br>• Perform a quiz after each unit.<br>• The exams and student participation. |
| 2 Other Strategies for Evaluation of Teaching by the Instructor or by the Department |
| 3 Processes for Improvement of Teaching<br>• Continuous updating of the course content.<br>• Looking for more clarifying examples.<br>• Continuous assessment of student's acquiring of knowledge and skills |
| 4. Processes for Verifying Standards of Student Achievement (e.g. check marking by an independent member teaching staff of a sample of student work, periodic exchange and remarking of tests or a sample of assignments with staff at another institution)<br>Discussion of the course objectives, teaching strategies, exams, students learning abilities and achievements, with other colleagues. |
| 5. Describe the planning arrangements for periodically reviewing course effectiveness and planning for improvement.<br>Continuous evaluation of the students during the term, and frequent updating of the course content. |

Name of Instructor: ______________________________________________

Signature: ______________________ Date Report Completed: __________

Name of Field Experience Teaching Staff ________________________________

Program Coordinator:______________________________________________

Signature: ______________________ Date Received: ________________