AST 5760: Computational Astrophysics
ISC 5415: Computational Space Physics

Catalog Description

This course offers introduction to numerical methods in the context of observational and theoretical astrophysics. The course covers interpolation, approximation, minimization and optimization, solution of linear systems of equations, random number generation, function integration, numerical differentiation, numerical integration of ordinary differential equations, stiff systems of ODEs, survey of methods for partial differential equations (Poisson equation, heat diffusion, hydrodynamics).

Credit

3 semester hours

Pre-requisites

MAC 2312, or the permission of the instructor; basic programming skills in Fortran, C, or C++.

Objectives

At the end of the course, the student will be able to

- discuss, present, and apply methods and techniques used in numerical computations in astrophysics,
- develop, implement, and use numerical methods in application to problems in theoretical astrophysics;
- analyze and interpret the results of numerical simulations including limitations imposed by observational and numerical discretization errors;
- present the results of computer simulations in form suitable for presentation in literature.

Main Topics

(a) differential equations, ODE integration; (b) gravitational N-body problem, self-gravity; (c) hydrodynamics, finite difference, finite volume, and SPH methods; (d) plasma degeneracy, stellar equation of state; (e) nuclear reactions, fusion; (f) heat conduction, flux limited diffusion, neutrino transport; (g) stellar evolution Henyey method.

Course Timeline

week	major topics covered
1	Astrophysics and computational science, three legs of science
2	Classical N-body methods, restricted 3-body problem, Roche lobe geometry
3	Specialized N-body methods, treecodes
4	Hydrodynamics, Boltzmann equation
5	Hydrodynamics, Euler and Navier-Stokes equations
6	Smoothed Particle Hydrodynamics
7	Grid-based hydrodynamics, finite difference methods
8	Grid-based hydrodynamics, conservation laws, finite volume methods
9	Compressible hydrodynamics, shocks
10	Transfer of heat and radiation
11	Stellar evolution: stellar equation of state, self-gravity, hydrostatic equilibria
12	Stellar evolution: opacity, radiative transport, convection
13	Stellar evolution: Henyey method
14	Stellar evolution: nuclear reactions, neutrino transport

Instructor

Instructor: Tomasz Plewa
Office: 415 DSL
Office phone: (850) 644-1959
E-mail: tplewa@fsu.edu
Office hours: by appointment.

Textbooks

- online lecture and computational laboratory materials
- required: P. Bodenheimer, G. P. Laughlin, M. Rozyczka, H. W. Yorke, *Numerical Methods in Astrophysics* (Taylor & Francis), 2006, 1st Edition, ISBN-10: 0750308834

Website

http://people.sc.fsu.edu/~tplewa/Teaching/ISC_5415/index.html

Homework Submission

Each homework assignment or project must be submitted as a single pdf document describing the solution process and presenting results with relevant code sources, input files, graphs, and images via email to the Instructor (tplewa@fsu.edu).

Grading

The course grade will be based on 3 tests (30%), short reviews of the recent popular science articles and homework assignments (20%), and computer lab-type projects (50%). No mid-term or final exams will be given. Late homework submissions will be subject of 10% points reduction per day, with the maximum of 50% points reduction.

The scale for the grades will be A (90-100%), A- (87-89%), B+ (83-86%), B (77-82%), B- (73-76%), C+ (69-72%), C (63-68%), C- (59-62%), D+ (55-58%), D (50-54%), and F (<50%).

University Attendance Policy

Excused absences include documented illness, deaths in the family and other documented crises, call to active military duty or jury duty, religious holy days, and official University activities. These absences will be accommodated in a way that does not arbitrarily penalize students who have a valid excuse. Consideration will also be given to students whose dependent children experience serious illness.

Academic Honor Policy

The Florida State University Academic Honor Policy outlines the University's expectations for the integrity of students' academic work, the procedures for resolving alleged violations of those expectations, and the rights and responsibilities of students and faculty members throughout the process. Students are responsible for reading the Academic Honor Policy and for living up to their pledge to ". . . be honest and truthful and . . . [to] strive for personal and institutional integrity at Florida State University." (Florida State University Academic Honor Policy, found at http://fda.fsu.edu/Academics/Academic-Honor-Policy.)

Americans with Disabilities Act

Students with disabilities needing academic accommodation should:
(1) register with and provide documentation to the Student Disability Resource Center; and
(2) bring a letter to the instructor indicating the need for accommodation and what type. This should be done during the first week of class.

Please note that instructors are not allowed to provide classroom accommodation to a student until appropriate verification from the Student Disability Resource Center has been provided.

This syllabus and other class materials are available in alternative format upon request.

For more information about services available to FSU students with disabilities, contact the:

Student Disability Resource Center
874 Traditions Way
108 Student Services Building
Florida State University
Tallahassee, FL 32306-4167
(850) 644-9566 (voice)
(850) 644-8504 (TDD)
mailto:msdrc@admin.fsu.edu
http://www.disabilitycenter.fsu.edu/

Free Tutoring from FSU

On-campus tutoring and writing assistance is available for many courses at Florida State University. For more information, visit the Academic Center for Excellence (ACE) Tutoring Services' comprehensive list of on-campus tutoring options - see http://ace.fsu.edu/tutoring or contact tutor@fsu.edu. High-quality tutoring is available by appointment and on a walk-in basis. These services are offered by tutors trained to encourage the highest level of individual academic success while upholding personal academic integrity.

Syllabus Change Policy

Except for changes that substantially affect implementation of the evaluation (grading) statement, this syllabus is a guide for the course and is subject to change with advance notice.