Syllabus: PHYS 424 Plasma Physics

Tuesday & Friday 11:10-12.25PM Rom 1000B (Macintosh Lab) Hunter North Bldg. 10th floor.

Instructor: Prof. Rodney L. Varley, Department of Physics and Astronomy
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Textbook: *Introduction to Plasma Physics and Controlled Fusion Volume 1: Plasma Physics,* 2nd Edition by Francis F. Chen (Plenum Press, 1984) ISBN 0-306-41332-9

Prerequisites: One year of introductory physics with Calculus PHYS 111 and PHYS 121 or the equivalent; Three semesters of Calculus. Also PHYS 334, Electricity and Magnetism is required OR the permission of the instructor. Little background in statistical physics or thermodynamics is required. PHYS 335 Intermediate Mechanics and PHYS 330 Atomic and Nuclear Physics are NOT pre-requisites for PHYS 424. The student is expected to have had three semester of calculus (or equivalent). A course in (ordinary or partial) differential eqt. is NOT a pre-requisite for this course. In particular MATH254 is NOT required for this course. The necessary aspects of partial differential equations for this course will be taught during this course. A course in computer programing is NOT required for this course. However, previous knowledge by the student of using a personal computer is expected. This class will be taught on Macintosh PowerPC computers and if the student in unfamiliar with the Macintosh, an introduction will be given.

Course Description: Plasmas are considered a fourth state of matter and are what results when a gas is heated to the point where the molecular collisions are strong enough to cause the atoms to break up into the constituent protons, neutrons and electrons. This state typically happens at temperatures of a million degrees Kelvin or more and this occurs in most stars including our Sun due to nuclear fusion so plasma is the dominant state of ordinary matter in our Universe. Nuclear fusion is the process whereby light atoms like hydrogen combine or fuse into heavier atoms like helium and as a result mass is converted into energy. The solar wind is in the plasma state so this is important in space physics and there are numerous practical uses of plasmas on Earth including magnetohydrodynamics power generation. There is also a hope that fusion might be a source of large scale power on Earth but there are numerous practical and theoretical problems which need to be overcome.

Some Topic Covered: The concept of temperature; the conditions of density and temperature necessary for the plasma state; discussion of fusion; motion of single charged particles in static and time varying electric and magnetic fields; plasmas described as (charged) fluids or magnetohydrodynamics; waves in plasmas; plasma heating with radio waves; kinetic theory description of plasmas including diffusion with and without magnetic fields; Debye shielding of a charge; Vlasov equation and collisionless plasmas; Landau dampening of waves; BGK single relaxation time model description of collisions; transport calculations of mass (diffusion); momentum (viscosity) and energy (heat conductivity).

Classroom Organization: Lecture notes will be posted as *Mathematica* notebooks. Each student will be supplied with a copy of Mathematics for use on their home computer. Having the lecture notes as *Mathe-*

matica notebooks is especially useful as embedded in the notebook are computational examples which the student can easily use. A hand calculator will NOT be necessary for this course as the *Mathematica* software will be used for numerical computations, programing and graphing. Having *Mathematica* available is especially helpful for this statistical and thermal physics course as the necessary integrals are easily performed using *Mathematica*. HOMEWORK will be handed in as *Mathematica* notebooks. *Mathematica* allows the student to easily write equations as well as text. The homework sets will be emailed from the student to the instructor for grading and the graded homeworks will be emailed back to the student. The same *Mathematica* notebooks may be used (without modification) on either Macintosh of WINTEL PC computers so if you have a WINTEL PC at home this is alright.

Obviously this is <u>not</u> a course chiefly about *Mathematica;* however, *t*hrough this course a beginner will learn how to use *Mathematica* in an elementary and useful way. It is understood that by taking this course, the student will learn *Mathematica*. However, the student should NOT expect to become a *Mathematica* "expert" as a result of this course.

This class is conducted in an "electronic classroom" having 15 Macintosh computers for student use. By the way, this means PHYS424 is limited to 15 students. Part of each class period will be a lecture of course material by the instructor and the remainder of the class time will be spent by the students doing "workshops" which are basically assigned problem sets. The instructor will help the students on their workshops during this class time. Students are expected to work with a partner (not alone) on exercises (workshops) that are assigned during class. These workshops will be joint work and a joint grade will be assigned to each group of two students. At least some of the problems on the midterm and final exams will be similar to the workshop problems so it is strongly suggested the student correctly complete the solution of the workshops. It is REALLY, REALLY IMPORTANT that each student (working in pairs) understand and do the ACTUAL WORK. Otherwise, when it comes time for the exam, the student who has NOT done the actual work will get a LOWER grade (and perhaps FAIL) the exam.

It will often be necessary for the student to do homework (outside of class time) on the workshops as there will not be sufficient time in class to complete the work. For this purpose, the students may use (Macintosh or Wintel) computers at Hunter College or at home. A large number of computers at Hunter College (10th floor North Bldg, Math Learning Center, and Physical Science Learning Center etc.) have *Mathematica* available. Also, the Hunter College Student Computer Fee (actually supplied by CUNY) allows each student a copy of *Mathematica* for home use. This is one of the benefits of being a student at Hunter College.

The course EXAMS will involve some traditional paper and pencil type problems as well as some computational problems. *Mathematica* can be used for numerical calculations on some problems by each student working individually on a computer in the classroom during the exam time.

Examinations: There will be two midterm exams and a final exam covering all the course material. Tentative dates for these exams are given on the schedule of classes. The highest of the two midterm exams will count toward the final course grade (the midterm exam with the lowest grade will be dropped). There will be NO MAKEUPS for the midterm exams. If one midterm exam is missed, then the other

midterm exam will automatically be the highest midterm exam and will be counted toward the course grade. If a student misses both midterm exams, then the contribution of the midterm exam toward the final course grade will be ZERO. If a student misses the final exam, the course grade will be INCOMPLETE *provided* the student is passing the course up to that time. A makeup exam will be given the sixth week of the fall 2004 semester and is administered by the Office of Student Services. Please register with Student Services on the 10th floor of the Hunter East Bldg. Note a fee is charged by Student Services.

Grading Scheme:

Workshops and quiz grades	20%
Midterm Exam	35%
Final Exam	45%

CLASSROOM ATTENDANCE IS EXPECTED AND IS REQUIRED! If you must miss a class bring an written excuse. Since quizes or workshops will be assigned and/or collected nearly each class period, these will serve as indication of attendance. Approximately 10-12 workshops will be assigned during the semester.

The CREDIT/NO-CREDIT was instituted to encourage students to take courses outside their major area of study. Courses like PHYS 424 are consider part of the physics major area of study and therefore CREDIT/NO-CREDIT is NOT available to physics students. CREDIT/NO-CREDIT will be available to someone whose major is say mathematics, chemistry, biology, and computer science. Should you choose the use the CREDIT/NO-CREDIT system of grading, you must submit the form to the instructor BEFORE the final exam paper is handed out the last day of class. In particular, you cannot ask for a CREDIT/NO-CREDIT after the final exam is taken.

Bring your own Zip disks to class to save your work and hand in homework. This course is largely a "paperless" course. The student will be instructed on how to save their work on a Zip. However, it is the student's responsibility to save their *Mathematica* notebook in the proper place (i.e. on the Zip) before the end of class especially at the end of an exam. BTW as usual the student is strongly advised to save their work frequently during the class as sometimes computers "crash" and should this happen, the work is usually lost.

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