ESS 472 (5 credits): High Altitude Research Projects

Purpose

This course will provide upper division laboratory experience for students interested in space science and engineering systems. This is especially needed in the ESS department, which currently has no such hands-on offering. This course will provide significantly more depth than is possible in the introductory ESS 205 class, which lacks pre-requisites and is accessible to non-science majors.

Within a team environment, students will build and launch a payload to high altitudes. In lectures, students will learn the underlying science motivation, the theory of the instrumentation, of science payloads, and of space science delivery systems. Science payloads and launch vehicle may change from year to year, depending on the project objectives. The course has these specific learning objectives:

- acquire experience in working as a member of a team, whose goal is to deploy a component of an integrated system that will address advanced science or engineering questions.
- learn and exercise design skills, and fabrication, testing, qualification, and calibration procedures, as necessary steps in the completion of the class project.
- learn how to evaluate and criticize alternate plans

Assessment

Students will be assessed on the following required work:

1. Production of weekly progress reports, to be evaluated by the instructor. These will contain detail about the student's and team's recent progress, and describe schedule status with regard to remaining tasks. These reports comprise an essential communication tool in a team project. Reports will be graded with respect to content and clarity of exposition.
2. Delivery of a brief oral report about science and engineering topics related to the project. This is meant to allow the student to explore and share material of personal interest that is related to the project, but outside of the nominal lecture plan.
3. A current log book and project documentation. This is the primary documentation of the student's progress in the laboratory exercises and cumulative work in the course. The log book will be examined regularly by the instructor to identify satisfactory progress and weaknesses in comprehension of the lecture or laboratory material.
4. A final report that details the entire project, the student's specific responsibilities, and an evaluation and interpretation of findings. This will be a document distilled from the student's cumulative project documentation, emphasizing the student's specific participation and their evaluation of their own progress. The instructor will evaluate this report at the close of the summer session.
5. Participation in two review processes, in which each team presents and defends their own plans and status, and in which teams criticize and evaluate plans and status of other teams. Students will be assessed on the quality of their presentations, and their insight and comments as reviewers of other presentations.
6. Demonstrate proficiency in one of several essential skills, such as design, construction, data analysis, or management. Supportive evidence could consist of objects such as a design file, an item manufactured by the student, a report interpreting results of a data analysis effort, or demonstrations of used management tools.

Prerequisites

The equivalent of PHYS 121, 122 (two quarters of basic physics), and the equivalent of at least one of the following: ESS 205, PHYS 334, EE 233, AA 320 (elementary electronics).

Summer 2007 Project

The science project this year investigates the relation between cosmic rays and electrical properties of the atmosphere. We will build instruments to make appropriate measurements (cosmic radiation flux, atmospheric electrical conductivity, and electric fields) and deploy the instruments on a high-power amateur rocket to collect data within the troposphere. The rocket(s) will be launched during the first week of August, from an off-campus site.

Curriculum (5 credits)

Lectures will occur 3 days a week, one hour each day, and be followed by a 3 hour lab period. Instruments and testing fixtures will be fabricated during the lab portion.

Lectures Syllabus for Summer 2007
Week 1: (a) introductory material; (b) amplifiers and negative feedback, stability; (c) radiation detectors—principles, various types
Week 2: (a) atmospheric electrical measurement techniques; (b) fundamentals of analog circuit design; (c) interfaces (mechanical, thermal, data, power)
Week 3: (a) how to test; (b) fundamentals of circuit layout
Week 4: (a) atmospheric structure (description of layer structure, role of radiation); (b) principles of rocket propulsion; (c) principles of rocket construction
Week 5: (a) rocket systems (power, data, attitude, etc); (b) cosmic radiation (sources, propagation, interaction with atmosphere); (c) Atmospheric electricity
Week 6: (a) balloons as a vehicle for science payloads; (b) spacecraft as a vehicle for science payloads (orbital mechanics, radiation environment, power, charging); (c) small project management (requirements flow, task outlines, scheduling, identifying and mitigating risks)
Week 7: (a) system integration; (b) readiness review; (c) spare time
Week 8: (a) Analyzing data and constructing a report; (b) oral reports; (c) oral reports

Laboratory Syllabus for 2007
Week 1: (a) introduction to equipment; (b) opamps; (c) prototyping 1
Week 2: (a) prototyping 2; (b) investigate lab versions of payload instruments; (c) instrument design 1
Week 3: (a) instrument design 2; (b) instrument design 3
Week 4: (a) layout/mechanical 1; (b) layout/mechanical 2; (c) design review
Week 5: (a) spare time; (b) harness and mechanical build-up; (c) electronics assembly 1
Week 6: (a) electronics assembly 2; (b) function testing; (c) qualification testing
Week 7: (a) system integration; (b) readiness review; (c) spare
WEEKEND: travel to launch site and launch rocket(s)
Week 8: (a) oral reports 1; (b) oral reports 2; (c) oral reports 3
The target number of students is 20, with students breaking up into 3–5 groups. Each group will have responsibility for a specific instrument from the complement comprising the complete payload. The rocket and some of its common support functions, such as power, data collection, and rocket recovery, will be provided to the class.

Documentation

A class web site on a department server will be maintained that allows the students to upload documentation for instruments and hardware so that other students can review the documentation.