EPET 301 ME 301: Space Science & Instrumentation

Course Description

Essential techniques for remote compositional analysis of planets; understanding spectroscopy, mineralogy, and geochemistry of planetary surfaces and their measurement. Design of space flight instrumentation. The course is offered in Fall only.

Number of Credits

EPET 301 is a four-credit lecture/laboratory course. It is cross-listed as ME 301. The course is co-taught with ERTH 404.

Relation to Curriculum

EPET 301/ME 301 is an integral part of the EPET certificate program.

Prerequisites:

EPET/ME 201, or ERTH 101 and ERTH 101L and ERTH 105; or ERTH 101 and ERTH 107; and CHEM 161 and PHYS 272.

Class contact hours

Under COVID provisions the course is delivered as asynchronous hybrid. General class meetings are synchronous online with two TR 3-hour meetings per semester week. For laboratory and practice class will be split. Small class sections will meet F2F during the first weekly instruction day, while non-lab sections will meet online; to be reversed on the second weekly instruction day. Upon return to regular F2F instruction there will be two TR 3-hour meetings per semester week.

Course Details

The course is structured into learning modules generally aligned with semester weeks. The lecture/laboratory course structure allows about 50% of instruction time for lectures and lecture activities and about 50% for laboratory activities and course project activities. The Model Content and Topics section provides an abbreviated list/description of course modules and course module activities. Lecture and laboratory activities support the learning objectives outlined in lecture topics. EPET 301/ME 301 project activities focus on the conceptualization and design of space instruments able to complete defined space mission objectives. This EPET 301/ME 301 class project design will be used in the EPET 401/ME 401 Capstone Project - Producing a science satellite.

Course delivery

The main elements of course delivery are mini-lectures, guided group discussions, and project-based learning activities. Students are engaged in studying foundational publications in the field of planetary science and are asked to critically evaluate research design, data acquisition, and data analysis and research outcomes.

The laboratory component of the course is characterized by the integration of theory and practice. In the initial weeks break-out group work and group discussions focus on practice and real problems underpinning lecture topics. Each of the break-out groups reports on the result of the exercise, leading to the advancement of the session topic. Later in the semester, break-out group work will increase in time to about half of the time assigned to the lecture component on a weekly basis.

Learning objectives are integrated through and culminate in a group-based research project: the design of an instrument for a planetary exploration mission. The requirement is to deliver a design that can be built/implemented during the EPET 401/ME 401 Capstone Project: Producing a science satellite.

Textbook

Selected chapters from:
Remote Compositional Analysis: Techniques for Understanding Spectroscopy, Mineralogy, and Geochemistry of Planetary Surfaces, Editors: Janice L. Bishop, Jeffrey E. Moersh, and James F. Bell, III. Publisher: Cambridge University Press 2019

Selected chapters from:
Remote Sensing Tools for Exploration: Observing and Interpreting the Electromagnetic Spectrum, Pamela Elizabeth Clark and Michael Lee Rilee, Springer, 2010.
General background, available to course participants:

Remote Geochemical Analysis: Elemental and Mineralogical Composition, Carle M. Pieters and Peter A.J. Englert, Cambridge University Press 1993.

<u>Model Content and topics</u>

Module 1
Lecture, Lecture activities: Setting the stage; Overview over remote sensing; Principles of planetary surface components; Lecture demonstrations, tutorials, problem solving.
Lab activities: Basic remote sensing problems; labs on mineralogy and remote sensing.

Module 2
Lecture, Lecture activities: Optical and infrared remote sensing principles. Basic optical sensor system design; sensitivity and its calculations.
Lab activities: Optics lab; ray-tracing; detector lab experiments.

Module 3
Lecture, Lecture activities: Vibrational spectroscopy (Raman) and florescence; remote Raman and fluorescence spectroscopy systems.
Lab activities: Optics lab
Project activities: General project brief 1

Module 4
Lecture, Lecture activities: High energy spectroscopy, radiation detection and measurement, basic radiation detector design, sensitivity and response calculations.
Lab activities: Radiation detection lab; interaction of radiation with matter; calibration of high energy radiation detectors.
Project activities: General project brief 2

Module 5
Lecture, Lecture activities: Phenomenology of planetary materials visible and near-infrared; Science traceability matrix.
Lab activities: Introduction to ENVI, terrestrial remote sensing examples.
Project activities: Selection of class projects

Module 6
Lecture, Lecture activities: Raman spectroscopy of planetary and astrobiology materials; fluorescence imaging and spectroscopy.
Lab activities: Raman light sources, radiation detectors and measurements.
Project activities: Research project work: definition.

Module 7
Lecture, Lecture activities: High energy spectroscopy: planetary surface radiation sources, radiation transport codes and orbital measurements; Monet Carlo simulations.
Lab activities: radiation transport calculations; mass absorption coefficient.
Project activities: Research project work: definition. Preliminary project definition paper due.

Module 8
Lecture, Lecture activities: Visible and thermal applications to planetary problems; lunar poles; Asteroids/Ceres Dawn; Mars.
Lab activities: ENVI laboratory.
Project activities: Review of class research project; proceeding to advanced definition.

Module 9
Lecture, Lecture activities: High energy spectroscopy and remote sensing (UV to gamma rays, alphas, neutrons); Lecture demonstrations, tutorials, problem solving.
Lab activities: High energy radiation detectors and measurements.
Project activities: Research project work: advanced definition.

Module 10
Lecture, Lecture activities: High energy spectroscopy applications to planetary problems, Moon; Asteroids/Vesta/Ceres/ Psyche; Mars, Mercury.
Lab activities: Qualitative and quantitative analysis of high energy radiation data.
Project activities: Research project work. Final project definition paper due.

Module 11
Lecture, Lecture activities: Review of optical spectroscopy, high energy spectroscopy.
Lab activities: Raman instrumentation, Remote Raman; Fluorescence imaging and spectroscopy.
Project activities: Final project definition review; implementation of class research project.

Module 12
Lecture, Lecture activities: Planetary Mission constraints on optical instrument design.
Lab activities: ENVI laboratory, problem solving.
Project activities: Research project work: instrument definition and design.

Module 13
Lecture, Lecture activities: Review of Raman spectroscopy, high energy spectroscopy.
Lab activities: Science traceability exercise.
Project activities: Research project work: instrument definition and design.

Module 14
Lecture, Lecture activities: Laboratory analytical techniques.
Lab activities: Laboratory analysis of extraterrestrial materials.
Project activities: Research project work: instrument definition and design

Module 15
Lecture, Lecture activities: CubeSat Project
Project activities: Research project completion

Module 16
Lecture, Lecture activities: Project paper PowerPoint presentation
Project activities: Project paper completion and submission