Master Syllabus: 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. Significant oral and written communication is required for this course. 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. A proposal to co-teach the course with ERTH 404 in a ‘stacked’ arrangement is pending.

Relation to Curriculum
EPET 301/ME 301 is an integral part of the EPET certificate program and the Aerospace Engineering concentration in Mechanical Engineering (ME).

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

Class contact hours
Regular F2F instruction has two 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 one third of instruction time each for lectures and lecture activities, for laboratory activities and course project activities, and for oral communication and writing support. The Model Content and Topics section provides a list/description of course modules and course module activities. 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.

The design/research project has several standard steps/phases that require both oral and written communication, concluding with a PowerPoint document and group presentation, and a research paper. The four mandatory steps/phases are 1. A Project concept report (paper). 2. A preliminary design review (paper and presentation). 3. A final design review (paper and presentation). And 4. A project summary review (paper and presentation).

Course Evaluation
Course grades will be based on ten homework assignments and the completion of a group research/design project on planetary exploration instrumentation.

For the first project step (outlined above) students have to provide a written project concept report. For the next three steps students will present their project progress in a preliminary and final design review, and a project summary review. Oral presentations using PowerPoint and written documents supporting the reviews are required, as outlined in the table below.

Homework assignments, concept paper, oral presentations and review papers are graded.
<table>
<thead>
<tr>
<th>Assignment</th>
<th>Min # of Pages</th>
<th>Pages/Student</th>
<th>% of Grade</th>
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<tbody>
<tr>
<td>Homework</td>
<td></td>
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<td>10</td>
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<tr>
<td>Project concept paper</td>
<td>6</td>
<td>2</td>
<td>5</td>
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<tr>
<td>Prelim. design review paper</td>
<td>18</td>
<td>4</td>
<td>10</td>
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<tr>
<td>Prelim. design Presentation</td>
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<td>15</td>
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<tr>
<td>Final design review paper</td>
<td>18</td>
<td>6</td>
<td>10</td>
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<tr>
<td>Final design presentation</td>
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<td>15</td>
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<tr>
<td>Summary review paper</td>
<td>18</td>
<td>6</td>
<td>20</td>
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<tr>
<td>Summary presentation</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
<td><strong>6</strong></td>
<td><strong>100</strong></td>
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**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. 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:

General background, available to course participants:


**Model Content and topics**

**Module 1**

**Lecture, Lecture activities**: Introduction; Optical and Infrared Remote Sensing Principles

**Lab activities**: Optics lab

**Project activities**: none

**Writing activities**: Introducing the Writing Intensive focus; lecture and lecture materials on writing science/engineering papers.  *WLO1*

**Oral communication activities**: Introducing the Oral Communication Intensive focus.
Module 2
Lecture, Lecture activities: Basic optical sensor system design; sensitivity and its calculation; science traceability.
Lab activities: Ray-tracing; detector lab experiments; traceability experiments.
Project activities: Establishment of teams for project; initial discussion on mission science justification and payload design; general project brief.
Writing activities: Workshop on scope of project concept paper, initiating draft writing of project concept paper. WLO2, WLO3
Oral communication activities: lecture on oral presentations in science and engineering OLO1-4

Module 3
Lecture, Lecture activities: Introduction high energy spectroscopy; high energy spectroscopy in space.
Lab activities: Radiation detection lab.
Project activities: Group project work on concept.
Writing activities: Project concept draft paper submission for review WLO4
Oral communication activities: Example technical preliminary design review presentation. OLO1-4

Module 4
Lecture, Lecture activities: Active Spectroscopic Systems; Raman and Fluorescence
Lab activities: no lab
Project activities: Group project work on preliminary design.
Writing activities: Project concept draft paper discussions WLO2,3&4; project concept paper submission for grading. WLO1-4
Oral communication activities: Example technical final design review presentation. OLO1-4

Module 5
Lecture, Lecture activities: High energy spectroscopy; Radiation detection and measurement; Basic radiation detector design
Lab activities: Radiation detection lab; Interaction of radiation with matter lab; Calibration of high energy radiation detectors.
Project activities: Group project work preliminary design.
Writing activities: Workshop on scope of preliminary design paper WLO1; initiating preliminary design paper draft writing. WLO3&4
Oral communication activities: Workshop on scope of preliminary design presentation. OLO3&4

Module 6
Lecture, Lecture activities: Phenomenology of planetary materials; visible and near-IR; Infrared
Lab activities: Introduction to ENVI; Terrestrial Remote Sensing Examples
Project activities: Group project work preliminary design.
Writing activities: Preliminary design paper draft discussion and submission for review. WLO2,3&4
Oral communication activities: Preliminary design presentation drafting and review. OLO3&4

Module 7
Lecture, Lecture activities: Phenomenology of planetary materials; Raman, Fluorescence
Lab activities: Raman lab
Project activities: Preliminary design review
Writing activities: Preliminary design paper submission for grading. WLO1-4
Oral communication activities: Preliminary design review presentation; discussion and feedback. OLO1&2

Module 8
Lecture, Lecture activities: Phenomenology of planetary materials; X-ray; Gamma / neutrons
Lab activities: Introduction to analysis of high energy radiation; Gamma / neutrons
Project activities: Group work on final design.
Writing activities: Workshop on scope of final design paper WLO1; initiating final design paper draft writing. WLO3&4
Oral communication activities: Workshop on scope of final design presentation. OLO1-4

Module 9
Lecture, Lecture activities: Visible and Thermal IR applications to planetary problems; Lunar Poles; Asteroids/Ceres/Dawn; Mars
Lab activities: ENVI Applications to Planet Problems; Moon, Mars Vesta data
Project activities: Group work on final design
Writing activities: Check on final design draft paper progress WLO3&4
Oral communication activities: Check on final design presentation progress. OLO3&4

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; from Lunar poles, Mars, Vesta, Ceres
Project activities: Group work on final design
Writing activities: Submission of final design draft paper for review. WLO1-4
Oral communication activities: Final design presentation drafting and review. OLO3&4

Module 11
Lecture, Lecture activities: Active spectroscopy applications to planetary problems; Mars; Moon; Asteroids
Lab activities: Raman instrumentation, Remote Raman; Fluorescence imaging and spectroscopy.
Project activities: Final design review
Writing activities: Discussion of final design draft paper and submission for grading.
Oral communication activities: Final design review presentation; discussion and feedback OLO1&2

Module 12
Lecture, Lecture activities: Planetary Mission constraints on optical instrument design.
Lab activities: work constraint problems
Project activities: Completing design project
Writing activities: Workshop on scope of summary review paper requirements WLO1; initiating summary review paper draft writing. WLO 2,3&4
Oral communication activities: Workshop on scope of summary review presentation. OLO3&4

Module 13
Lecture, Lecture activities: Planetary Mission Constraints on Optical Instrument design; High energy applications to planetary problems.
Lab activities: no lab
Project activities: Completing design project
Writing activities: Check on summary review draft paper progress WLO3&4
Oral communication activities: Check on summary review presentation progress. OLO3&4

Module 14
Lecture, Lecture activities: Laboratory analytical techniques.
Lab activities: Laboratory analysis of extraterrestrial materials (demos).
Project activities: Completing design project
Writing activities: Submission of summary review draft paper for review WLO2,3&4
Oral communication activities: Summary review presentation drafting and review OLO1&2

Module 15
Lecture, Lecture activities: CubeSat Project
Project activities: Project summary review
Writing activities: Discussion of summary review draft paper and submission for grading WLO1-4
Oral communication activities: Summary review presentation; discussion and feedback OLO1-4