Course Description
EPET 201 is an introductory course on the science and engineering of Solar System exploration. It covers science instruments, mission trajectories, mission planning, and science and engineering constraints on spacecraft design. Class projects require research with an emphasis on written communication. The course is offered in Spring only.

Number of Credits
EPET 201 is a three-credit lecture course. It is cross-listed as ME 201.

Relation to Curriculum
EPET 201/ME 201 is an integral part of the EPET Certificate program and the Aerospace Engineering concentration in Mechanical Engineering (ME).

Prerequisites
None

Class contact hours
Under COVID provisions the course is delivered asynchronous online. Post-COVID the course may remain to be offered online or return to a regular F2F TR semester schedule. The F2F course is planning several four-hour field trips outside of regular class meeting time.

Course Details
EPET 201/ME 201, Space Exploration, is an introductory course for the EPET certificate aimed at any science or engineering student interested in the history and technology behind Solar System exploration and the available resources on other planetary bodies. The course will introduce students to the diverse sets of robotic spacecrafts, rovers, and landers sent to explore the various planetary bodies in our Solar System over the past 60 years. Course topics will include the diverse suite of instruments used to collect a variety of data, flight plans (fly-by, orbiter, or lander) of planetary missions, the engineering constraints imposed on spacecraft design for different thermal and radiation environments, and the scientific discoveries made by these missions.

Students will explore the history of space exploration, the key attributes of different planetary bodies in the Solar System (e.g., planetary environments, atmospheric conditions, planetary materials, and degree and types of geologic activity), and the basics of sensor design and operation. Another critical aspect of planetary exploration and missions is teamwork, in which students must learn to cooperate and work together to accomplish goals. In this course, students will work in small teams to design their own hypothetical missions to a planetary object of their choice and to develop both a detailed understanding of an object in the Solar System as well as the spacecraft performance needed to investigate this body.

Research teams (groups) of three students are formed. The instructor will offer assignments from a limited (and prescribed) set of topics, and research teams will select a topic. The research topics expand major class lecture topics and support course learning goals.
Through in class research briefings the instructor will provide information on the research topics and provide key references. Lectures on science and engineering processes, a lecture and lecture materials on writing science/engineering papers, and a grading rubric will be provided. A timeline for the completion of aspects of the research work, the production of drafts and final versions of the research paper complete the team information.

**Course Delivery**

The main elements of course delivery are online or in-class lectures, online or in-class exercises, oral class presentation, and, when appropriate, field trips. These will be structured to provide a coherent picture of space science and exploration.

**Course Evaluation**

Course grades will be based on ten homework assignments and the completion of two group projects on the science and design of space missions to a planetary body.

For each project, student research groups are required to produce a concept and a final paper. Both the concept and the final paper are evaluated with respect to content as well as structure and formality of science and engineering papers (full editorial review). Students have the opportunity in an iterative an interactive process, to improve their papers to approach the standard format and outcome of a science and engineering paper. The two research papers need to fulfill all requirements of a standard science or engineering publication. Homework assignments and both, concept, and final papers are graded.

<table>
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<th>Assignment</th>
<th>Description</th>
<th>Min # of Pages</th>
<th>Pages/Student</th>
<th>% of Grade</th>
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<td>Project 1</td>
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<tr>
<td>Project 1</td>
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<tr>
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**Textbook/Course Materials:**

The online course may select a textbook to facilitate learning. The F2F course, when available, will direct students to journal articles and publicly available learning materials including videos and image files that focus on the exploration of the Solar System.

**Model Content and topics**

**Module 1: Introduction**

Background on history of Solar System research.
Inventory of the Solar System – size and attributes of the planets and moons.
Chronology of missions to planets and moons.

**Lab activities:** Demos for density, gravity, orbital motion of planetary bodies.

**Project activities:** none

**Writing activities:** Introducing the Writing Intensive focus; lecture and lecture materials on writing science/engineering papers. *(WLO1)*
Module 2: Terrestrial planets, asteroids, and moons
Formation of the Solar System
Properties of terrestrial planets and their moons, asteroids, and Titan
Atmospheres of terrestrial planets and Titan
Contrast between the Earth, Moon, Venus, and Titan
**Lab activities:** Demos and activities on craters, atmospheres of planetary bodies.
**Project activities:** Establishment of teams for project 1; initial discussion on mission design objectives
**Writing activities:** Introducing the scope of concept and research papers. (WLO1)

Modules 3: Jovian planets, icy bodies (comets), and dwarf planets
Properties of the Jovian planets, icy bodies, and dwarf planets.
Thermal and atmospheric properties of Jovian planets, icy bodies, and dwarf planets.
**Lab activities:** Demos and activities on density and magnetic fields of Jovian planets
**Project activities:** Project 1 team target selection and mission design objectives. Start of project 1.
**Writing activities:** Workshop on project 1 concept paper scope; initiating draft writing. (WLO2, WLO3)

Module 4: Science as a process & Mission goals
Science as a process: observation, hypothesis creation, hypothesis testing, hypothesis modification, publication/presentation.
Definition of science goals for space exploration missions.
**Lab activities:** Demo on science process, science traceability.
**Project activities:** Project 1 group work
**Writing activities:** Project 1 concept draft paper submission for review. (WLO4)

Module 5: Instrument payloads for planetary missions
Sensors for planetary exploration: physical methods of remote sensing
Modalities for observations from orbit
Modalities for observation from rovers/landers (on the ground)
Returned samples
**Lab activities:** Demos on planetary remote sensing modalities.
**Project activities:** Project 1 group work
**Writing activities:** Project 1 concept draft paper discussions (WLO 2,3&4) ; workshop on project 1 research paper scope (WLO1); Project 1 concept paper submission for grading (WLO 1-4).
**Field trip 1:** Bishop Museum (F2F delivery only)

Module 6: Engineering of spacecraft for planetary missions
Payload servicing and power generation and consumption
Communication and command systems
Data and communication constraints for payloads (How much data can a mission collect each day?)
Orbital constraints on data acquisition; examples of data plans.
Case studies: Galileo mission to Jupiter, New Horizons to Pluto, Lunar Prospector
Lab activities: Demos on satellite communication

Project activities: Project 1 group work

Writing activities: Check on research paper progress. (WLO2, WLO3)

Module 7: Designing a planetary exploration mission
Selection of object, mission goals, mission payload, and trajectory
Definition of launch, orbit insertion, mission objectives and lifetime.
Communication, command and control of spacecraft and payload.
Achieving mission goals; ending a mission
Case studies: NEAR mission, MESSENGER mission, DAWN mission

Lab activities: Case studies: NEAR mission, MESSENGER mission, DAWN mission

Project activities: Project 1 group work.

Writing activities: Project 1 research draft paper submission for review (WLO 2,3&4).

Modules 8: Pre- and post-Apollo lunar exploration missions
Lunar fly-bys, orbiters, and landers – a historical overview
Pre-Apollo orbiters and landers; Soviet rovers on the Moon; Post-Apollo orbiters and landers (including Chang’e 3 and Chang’e 4).

Lab activities: Demo on early lunar missions and results

Project activities: Project 1 group work.

Writing activities: Project 1 research draft paper discussions (WLO 2,3&4); submission of project 1 research paper for grading (WLO 1-4).

Module 9: The Apollo missions to the Moon; human exploration of space
Engineering background for the Apollo landings (from Mercury to Apollo 17).
The lunar regolith? (Hazards of landing).
The role of “dust” affecting hardware and astronauts.
The scientific return of the Apollo missions: observations from orbit, on the ground and returned samples. (Space labs and the International Space Station; the ARTEMIS project)

Lab activities: Case Study: In-class discussion of designing a future mission to the Moon.

Project activities: Project 2 team selection, target selection and mission design objectives. Start of project 2.

Writing activities: Workshop on project 2 concept paper scope; initiating draft writing. (WLO2, WLO3)

Module 10: Mars exploration with orbiters and landers
Mars orbiters and Landers – a historical overview (Mariner IV to Mars Reconnaissance Orbiter)
The Mars Odyssey mission.; Mars Exploration Rovers; Power and data constraints of MERs and MSL. Mars mission planning and the science team roles. Curiosity and Mars 2020

Lab activities: Demo on designing the Mars Odyssey gamma ray spectrometer

Project activities: Project 2 group work

Writing activities: Project 2 concept draft paper submission for review (WLO 2,3&4).

Field trip 2: HSFL laboratories; virtual reality laboratories (F2F delivery only)
Module 11: How do we land on Mars: from rovers to human exploration
Determination of surface topography, geology surface roughness and atmospheric structure; Landing site constraints; Role of atmosphere; Payload constraints and lander mass, the need for precision landing for science objectives, expected mission duration; rover range.
**Lab activities:** Case Study: In-class discussion of designing a future mission to Mars.
**Project activities:** Project 2 group work
**Writing activities:** Project 2 concept draft paper discussions (WLO 2,3&4); workshop on project 2 research paper scope (WLO2, WLO3); project 2 concept paper submission for grading (WLO 1-4).

Module 12: Exploration of Jovian Planets, their satellites, and other icy bodies
Outer solar system exploration – a historical overview
The Voyager story.
Cassini and Saturn’s moons.
Rosetta at Comet 67P.
**Lab activities:** Case studies: Galileo mission to Jupiter, Cassini mission to Saturn, and New Horizons to Pluto
**Project activities:** Project 2 group work
**Writing activities:** Check on research paper progress (WLO2, WLO3).

Module 13: Engineering requirements to investigate various environments
Terrestrial Planets and objects:
Roles of pressure and temperature on Venus; the Venera missions
Sampling an asteroid (OSIRIS-Rex, Hayabusa 1 & 2). Landing on a comet (NEAR, 67P)
Jovian Planets and moons: Jupiter’s radiation environment and missions to the planet and its moons (Io, Europa)
**Lab activities:** Demo effects of radiation on space detectors
**Project activities:** Project 2 group work
**Writing activities:** Check on research paper progress (WLO2, WLO3).

Module 14: Semester summary
In-class completion of student assignments of designing a future planetary exploration space mission.
**Lab activities:** none
**Project activities:** In class project 2 group work.
**Writing activities:** Project 2 research draft paper submission for review (WLO 2,3&4).

Module 15: Semester summary
In-class completion of student assignments of designing a future planetary exploration space mission.
**Lab activities:** none
**Project activities:** Completion of project 2 group work.
**Writing activities:** Project 2 research draft paper discussions; project 2 research paper submission for grading (WLO 1-4).