EPET 201/ME 201: Space Exploration

Course Description
EPET 201 is an introductory course on the science and engineering of Solar System exploration. This course covers science instruments, mission trajectories (fly-by, orbit or lander), mission planning, and science and engineering constraints imposed on spacecraft design. There will be lectures, discussions, and class projects. The course is offered in Spring only.

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

Relation to Curriculum
EPET 201/ME 201 is an integral part of the EPET Certificate program.

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.

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 weekly homework assignments and the completion of two group projects on the design of space missions to a planetary body.

Textbook/Course Materials:
The online course may select a textbook to facilitate learning. The F2F course, wen 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

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: Introduction into planetary mission design

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: Establishment of teams for project 1; initial discussion on mission design objectives

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 team target selection and mission design objectives. Start of project 1.

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
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

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 draft group paper due.

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 final group paper due.

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; he ARTEMIS project)
Lab activities: Case Study: In-class discussion of designing a future mission to the Moon.
Project activities: Project 1 group project presentations. Project 2 team & target selection.

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
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

Module 13: 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

Module 14: 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

Module 15:
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. Project 2 draft group paper due.

Module 16:
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. Project 2 final group paper due.

Module 17:
Student presentations on space mission design.