AA 405 COURSE DETAILS

TITLE:	Introduction to Aerospace Plasmas
CREDITS:	3
FORMAT & SCHEDULE:	Lecture, 3 hours / week
FACULTY CONTACT:	Uri Shumlak

COURSE DESCRIPTION (Catalog Short Form, 50 words Max):

Development of introductory electromagnetic theory including Lorentz force and Maxwell's equations. Plasma description. Single particle motions and drifts in magnetic and electric fields. Derivation of plasma fluid model. Introduction to plasma waves. Applications to electric propulsion, magnetic confinement, and plasmas in space and Earth's outer atmosphere.

COURSE OVERVIEW & LEARNING OBJECTIVES:

Students completing this course in good standing will be able to:

1. Calculate the electric and magnetic fields for given electrode and current geometry.
2. List Maxwells equations and explain their significance.
3. Describe the Lorentz force and its source.
4. Determine charged particle motion in the presence of electric and magnetic fields.
5. Apply adiabatic invariants to determine particle trapping in Earth’s dipole field.
6. Explain the presence of the Van Allen radiation belts.
7. Describe the effect of the interplanetary magnetic field on Earth’s atmosphere.
8. Identify the 3 magnetohydrodynamic waves.
9. List the general types of electric plasma thrusters and their applicability.
10. Describe frozen flow losses in electrothermal thrusters.
11. Calculate the Child-Langmuir saturation thrust in electrostatic thrusters.
12. Differentiate among electromagnetic thrusters.
13. Design an electric plasma thruster for a particular mission and determine the thruster efficiency, power requirements, and compare to other options.
14. List some common fusion reactions and the energy released.
15. Explain the basic principles of magnetic plasma confinement.
16. Identify open and closed magnetic confinement configurations.

COURSE REQUIREMENTS

PREREQUISITES: 1) MATH 324
2) PHYS 123

REQUIRED TEXTBOOK:
1. *Introduction to Plasma Physics and Controlled Fusion* by F.F. Chen
2. *Introduction to Electrodynamics* by D.J. Griffith

COURSE SCHEDULE

Topics

Electricity and magnetism: electrostatics, magnetostatics, electrodynamics and Maxwell's equations, superposition principle for E-M fields, Poynting's theorem

Definition of plasma state: Debye shielding, plasma frequency, role of collisionality

Single particle motion in electric and magnetic fields: guiding center drifts, adiabatic invariants, magnetic mirrors

Fluid theory: 2-fluid model of plasma, derivation of MHD equations, resistivity and generalized Ohm's law, waves in plasma

Electric propulsion: specific impulse, Tsiolkovsky rocket equation, energy considerations

Electrothermal thrusters: resistojets, arcjets, frozen flow losses

Electrostatic thrusters: Child-Langmuir law, Hall-effect thrusters

Electromagnetic thrusters: conveyor belt problem, MPD arc, MHD thrusters

Magnetic confinement fusion: thermonuclear fusion reactions, Lawson criteria, magnetic confinement configurations

Space plasmas: solar wind, interplanetary magnetic field, Van Allen radiation belts