AE 4451 Jet and Rocket Propulsion (3-0-3)

Catalog Description: AE 4451 Jet and Rocket Propulsion. The theories and principles of jet and rocket propulsion. Thermodynamic cycles. The mechanics and thermodynamics of combustion. Turbine engine and rocket performance characteristics. Component and cycle analysis of jet engines and turbomachinery.

Text: Hill and Peterson, *Mechanics and Thermodynamics of Propulsion*, 2nd edition, Addison-Wesley.

Course Coordinator: Prof. J. Seitzman

Learning Objectives:

1. Familiarity with common types of aircraft and spacecraft propulsion systems.
2. Use of thermodynamic cycle analysis, including the thermodynamic treatment of chemically reacting systems.
3. Preliminary cycle design and performance analysis of propulsion systems for both aircraft and spacecraft.
4. Working knowledge of the basic operation and design requirements of propulsion turbomachinery components (inlets, compressors, combustors, turbines, afterburners, and nozzles).

Expected Outcomes: Students will be able to: a) make design choices between jet and rocket propulsion systems based on performance issues; b) calculate energy release, e.g., adiabatic flame temperatures, and equilibrium composition of gases at known temperature and pressure; c) analyze the thermodynamic performance of jet engine cycles and compute relevant performance parameters; d) perform preliminary design calculations to size jet engines to meet specific performance goals; e) analyze the thermodynamic performance of simple chemical and electrical rocket cycles and compute relevant performance parameters; and f) characterize the performance and operating/design constraints for inlets, compressors, combustors, turbines and nozzles.

Prerequisites: AE 3450

Topics:

1. **Overview**: Aircraft and spacecraft propulsion systems, general design goals
2. **Thermodynamics Review**: Conservation/Transport equations; Momentum conservation and thrust equations; Properties of perfect gases and perfect gas mixtures; Overview of propulsion systems
3. **Equilibrium Chemical Thermodynamics**: Chemical energy/heats of reaction and formation; Equilibrium composition
4. **Thermodynamic Cycle Analysis**: Carnot and Brayton cycles

5. **Airbreathing Engine Performance Parameters**: Specific thrust; Specific fuel consumption; Propulsive, thermal and overall efficiencies
6. **Jet Engine Cycle Analysis and Performance**: Ramjets; Turbojets; Turbofans; Turboprops and turboshaft engines
7. **Rocket Propulsion Analysis, Performance and Mission Requirements**: Overview of rocket propulsion systems; Specific impulse; Equivalent exhaust velocity; Vehicle acceleration, the rocket equation and mission requirements;
8. **Chemical Rocket Cycle Analysis**: Characteristic velocity and thrust coefficient; Propellant properties; Analysis of open and closed liquid rocket cycles; Solid propellant rocket analysis; Nozzle performance
9. **Electric and In-Space Propulsion**: Electrothermal; Electrostatic; Electrodynamic propulsion systems
10. **Inlet and Nozzle Analysis, and Design and Performance Issues**: Subsonic and supersonic diffusers/inlets; nozzles and thrust reversers
11. **Combustor Analysis, and Design and Performance**: Combustor configurations; Stability and flammability limits; Emissions; Choking of afterburners
12. **Compressor Analysis, and Design and Performance**: Axial v. centrifugal designs; Blade flow and work; Efficiency; Surge and stall; Compressor maps
13. **Turbine Analysis, and Design and Performance**: Cooling; Blade flow and work; Compressor matching