MAE 113
Fundamentals of Propulsion
(4 units)

Class/Laboratory Schedule: four lecture hours per week, eight hours outside preparation. 12 hours/week total

Course Coordinator(s): Kal Seshadri

Textbook and Required Materials: Jack D. Mattingly, Elements of Propulsion, Gas Turbines and Rockets, AIAA Education Series, 2006.

Course Catalog: Compressible flow, thermodynamics, and combustion relevant to aircraft and space vehicle propulsion. Analysis and design of gas turbines, inlets, compressors, combustion chambers, and nozzles. Fundamentals of rocket propulsion.

Prerequisites: Requires MAE 110A and MAE 101A, B, C with a grade of C- or better.

- ■ Required Course
- ☐ Technical Elective Course
- ☐ Other: _____

Performance Criteria:

Objective 1
1.1 Student will demonstrate ability to apply principles of analysis to formulate and solve problems involving air breathing engines

Objective 2
2.1 Student will demonstrate ability to apply principles of analysis to formulate and solve problems involving rockets

Objective 3
3.1 Student will demonstrate ability to analyze performance of cycles

Objective 4
4.1 Students will demonstrate ability to select appropriate propulsion devices for a given application

Objective 5
5.1 Students will demonstrate ability to analyze individual components

Objective 6
6.1 Students will demonstrate familiarity and understanding of system performance

Course Objectives:
(Numbers in parenthesis refer to MAE Program Outcomes)

Objective 1:
Provide students with an understanding of the use of thermodynamics, transport processes, and compressible flow fundamentals in the operation of air breathing engines (gas turbines). [1a, 3c, 5e, 9i, AE12]

Objective 2:
Provide students with an understanding of the use of thermodynamics, transport processes, and compressible flow fundamentals in the operation of rockets. [1a, 3c, 5e, 9i, AE13]

Objective 3:
Provide students with the ability to analyze the performance of gas turbine cycles and rocket engine cycles for propulsion [3c, 5e, AE12, AE13, AE14]

Objective 4:
Provide students with the ability to select appropriate propulsion devices (ramjet, turbojet, turbofan, turboprop, rocket) for a given application. [3c, 5e, 11k]

Objective 5: Provide students with the ability to analyze the operation of individual components of a gas turbine and rocket: inlets, compressor, combustor, turbine, afterburner, and nozzle. [1a, 3c, 5e, AE12, AE13, AE14]

Objective 6: Provide students with the ability to appreciate the influence of the performance of the components of the gas turbine and rocket engines on the system performance. [3c, 4d, 9i, 10j, AE14]

Course Topics:

1. Introduction: Propulsion, units, operational envelopes and standard atmosphere, air-breathing engines, aircraft performance, rocket engines

2. Review of Fundamentals: Equations of state, conservation of mass, conservation of energy, steady flow momentum equation, steady flow entropy equation, compressible flow properties, chemical reactions for propulsion applications.

3. Rocket Propulsion: Rocket propulsion requirements and capabilities, rocket propulsion engines, types of rocket nozzles, parameters for chemical rockets.

4. Aircraft Gas Turbine Engine: Thrust equation, propulsive, thermal, and overall efficiency, gas turbine engine components, Brayton cycle, aircraft engine design.

5. Parameter Cycle Analysis of Ideal Engines: Design inputs, ideal ramjets, ideal turbojet, ideal turbojet with afterburner, ideal turbofan, ideal turbofan with optimum bypass ratio, ideal turbofan with optimum fan pressure ratio, ideal pulse detonation engines.

6. Component Performance: Variation in gas properties, inlet and diffuser pressure recovery, compressor and turbine efficiencies, burner efficiency and pressure loss, exhaust nozzle loss.

7. Parameter Cycle Analysis of Real Engines: Turbojet, turbojet with afterburner, turbofan with separate exhaust streams.

8. Engine Performance Analysis: Gas generator, turbojet, turbojet with afterburner, turbofans.

9. Inlets, Nozzles, and Combustion Systems: Inlets, subsonic inlets, supersonic inlets, exhaust nozzles, introduction to combustion systems, main burners, afterburners.

Prepared by: F.A. Williams, K. Seshadri, March 2007
Reviewed: TWG, June 2010; August 2011, August 2012