

1. Course number and name  
**EML 4421 Fundamentals of Propulsion Systems**
2. Credits and contact hours  
 3 cr, 2.5 contact hours (2 hrs. 30 min. lecture)
3. Instructor's or course coordinator's name  
 Instructor: Dr. Rajan Kumar, Coordinator: Dr. Juan Ordonez
4. Text book, title, author, and year  
 Gas Turbine Theory, Saravanamuttoo, H. I. H., Rogers, G. F. C., Cohen, H., and Straznicky, P., 2008  
 Choice:
  - Engineering Fundamentals of the Internal Combustion Engine, Pulkrabek, W. W., 2003
  - Aerospace Propulsion, Lee, T. W., 2013
  - Rocket Propulsion Elements, Sutton, G. P. and Biblarz, O., 2010
  - b. *References, Additional Resources*
    - Engines, An Introduction, Lumley, J. L., 1999
    - Introduction to Thermodynamics and Heat Transfer, Cengel, Y. A., 2007
    - Introduction to Fluid Mechanics, Fox, R. W. and McDonald, A. T., 2003
    - Internal Combustion Engine Fundamentals, Heywood, J. B., 1988
    - Fundamentals of Gas Turbines, Bathie, W. W., 1995
    - Mechanics and Thermodynamics of Propulsion, Peterson, H., 2009
    - An Introduction to Aerospace Propulsion, Archer, R. D. and Saarlus, M., 1998
5. Specific course information
  - a. *brief description of the content of the course (catalog description)*  
 This course is a technical elective course designed for senior-level engineering students in the Aeronautics Track and area of thermal and fluid sciences. It emphasizes on the detailed analysis of the performance of traditional propulsion systems using fundamental principles of the thermodynamics, heat transfer and fluid mechanics. The course is subdivided into three parts: 1) the study of internal combustion (IC) /automotive engines and their analysis; 2) Gas turbine engines involving turboprop, turbojet, turbofan propulsion; and 3) Rocket propulsion engines using solid, liquid or hybrid fuel.
  - b. *prerequisites or corequisites*  
 Prerequisites: EML 3015C and EML 3016C
  - c. *indicate whether a required, elective, or selected elective course in the program*  
 Selected Technical Elective course
6. Specific goals for the course
  - a. *Course Outcomes*  
 Upon course completion, students should be able to:
    1. Be able to recognize the relevancy of fundamental thermal principles and their importance in the analysis of piston and gas turbine engines[1]
    2. Be able to calculate the performance of either an IC or a jet engine using idealized cycle analysis [3]
    3. Be able to recognize the differences between real and idealized cycles and perform corrected analysis of the ideal cycles using actual operating parameters [3]

4. Be able to recognize all major components of an IC, jet and rocket engine; be able to specify their functions and characterize their interrelationship in the operation of the system. [3, 4]
5. Be able to describe the differences in design for systems intended for different applications [5]
6. Be able to function in a group or as an individual to study and learn specific propulsion aspects of an engine system that have not been covered in the class and then be able to present finding to fellow students through an oral presentation in a formal classroom setting and submit results in a final report

Numbers refer to Course Objectives below, e.g. for course outcome 1, [1] refers to course objective 1.

*b. Course Objectives and Relation to Student Outcomes*

1. To understand the application of fundamental thermal disciplines, including thermodynamics, heat transfer and fluid mechanics, in the analysis of practical thermal systems such as IC, turbojet and rocket propulsion systems [1, 5]
2. To provide a comprehensive review concerning applications, technological advances, and social impacts on the modern development of engines [7, 8, 9]
3. To provide an overview of the operation of engine systems (IC, Jet and Rocket) [1, 5]
4. To analyze all major components in the propulsion system and their matching specifications [1,5]
5. To analyze the overall performance of the propulsion system [1,5]
6. To simulate the thermodynamic performance of engines using computational tools and to learn how numerical codes can be used for preliminary engine design analysis [3, 10]

Numbers refer to Departmental Student Outcomes, e.g. for course objective 1, [1, 5] refers to student outcomes 1, 5.

7. Brief list of topics to be covered

- Introduction and review of fundamental thermal sciences, including thermodynamics, fluid mechanics and heat transfer, and how they can be applied to the design/analysis of IC, jet and rocket engines
- Introduction of IC engines and their operations
- Thermodynamic considerations: Gas power cycles analysis
- Heat transfer and fluid mechanics of IC engine design
- Overall IC engine performance
- Introduction to jet propulsion systems and their operations
- Thermodynamic considerations: Gas turbine analysis
- Aerodynamics of propellers, fans, and rotors: actuator disk theory, momentum disk model, Betz limit
- Compressors, combustion chambers, turbines for gas turbine engines
- Overall jet engine performance
- Rocket propulsion involving solid, liquid and cryogenic fuels
- Thrust vector control and engine selection criteria