ME 490.03 Power for Mechanical Systems Spring 2021

This course will examine the requirements for powering a variety of mechanical systems and consider the characteristics of prime movers to deliver the necessary energy, torque and power. A design focus will be used to match different drive technologies including piston engines, gas turbines and electric motors to particular applications.

**Prerequisite:** Thermodynamics

**Instructors:** Josiah Knight [jknight@duke.edu](mailto:jknight@duke.edu), Robert Kielb [rkielb@duke.edu](mailto:rkielb@duke.edu)

**Class meetings:** W F 8:30-9:45 Online

**References:**
- Cumpsty, Nicholas and Andrew Heyes, JET PROPUSION, 3rd ed, Cambridge 2015
- Mohan, Ned, ELECTRIC DRIVES, MNPERE, Minneapolis, 2003
- Handout notes and slides

**Integrity:**

We will adhere to the Duke Community Standard in matters of academic integrity.

Homework may be collaborative; your goal is to gain and demonstrate understanding on tests and project work, but please write out your own individual solutions to assignments. On quizzes and tests you are required to submit only your own unaided work.

Be aware that this statement of expectations applies to this course and this term only. Other instructors, and these instructors in other courses, may have different expectations, and you should make sure you understand them in every case.

**Learning Objectives.** After this course, students will be able to:

Describe the general characteristics and operating principles of different prime movers.

List the broad considerations important to integrating engines and motors into mechanical systems.

Apply mathematical models, with appropriate assumptions and approximations, to describe the physical performance of engines and motors including torque, power and efficiency.

Use trade-off principles to make design decisions.

**Performance and Grading**

Three tests @ 25% each, homework assignments 20%, participation (incl attendance) 5%
Tentative schedule

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Tentative Topics

Overview of power requirements for mechanical systems
Piston engines layout and kinematics. Four stroke and two stroke engines.
Fuels, combustion and fuel delivery. Carburetion, injection, efficiency.
Monitoring and control. Sensors, spark, cooling, emissions reduction.
Turbines: Fundamental Principles, Thermodynamics, Efficiency & Work,
Turbines: Effect of Real Gas Properties, Simple Fluid Mechanics
Turbines: Scaling & Dimensional Analyses, Compressors, Turbines, Combustors,
Emissions, Matching
Turbine Vibrations: SDOF, MDOF, Modal, Resonant Response, Campbell Diagram
Turbine Aeroelasticity: Unsteady Aerodynamics, Aerodynamic Damping, Flutter
Electric motor overview. Principals relating current, field, force, motion
and emf in a wire and coil.
DC commutator machines. PM, shunt, series. Brushless motor basics.
Power supply and speed control for brushed and brushless DC machines.
AC motors. Induction, synchronous. 1-phase and 3-phase power. Power factor.