AE 6410 Combustion Dynamics (3-0-3)

Catalog Description: AE 6410 Combustion Dynamics. Analysis of acoustic wave propagation in inhomogeneous flows, flame-acoustic wave interactions, and control of combustion instabilities.

Text: *Combustion Driven Oscillations in Industry*, Abbot Putnam, Elsevier

Course Coordinator: Dr. Tim Lieuwen

Learning Objectives:

1. Teach fundamentals of wave propagation phenomenon in inhomogeneous environments, such as through ducts with variable area and temperature.
2. Teach fundamentals of unsteady flame-acoustic wave interactions, such as combustion noise and self-excited, combustion driven oscillations. Describe analytical and numerical approaches for modeling flame transfer functions.
3. Teach basic unsteady signal processing, such as Fourier transforms and autocorrelations. Discuss the measurement of unsteady pressure, heat release, and velocity.

Expected Outcomes: Students will be able to: 1) develop simplified models of combustion chamber acoustics, 2) predict stability of a combustor, 3) perform nonlinear perturbation analysis, and 4) analyze dynamic signals.

Prerequisites: Graduate level exposure to combustion.

Topics:

1. **Wave propagation and generation (6 lectures)**: Plane waves propagation, Radial and circumferential waves, Combustion noise generation
2. **Duct Acoustics (6 lectures)**: Longitudinal, radial, circumferential modes of oscillation, cutoff frequencies, Boundary conditions-open ends, closed ends, nozzles, Rapid expansions, flow obstructions, Mean flow effects, Temperature inhomogeneity effects
3. **Combustion Dynamics - Basic Concepts (9 lectures)**: Instability mechanisms-feed line coupling, vortex shedding, equivalence ratio oscillations, flame area oscillations, Small perturbation (linear) analysis, Nonlinear effects, Passive control approaches
4. **Combustion Dynamics - Advanced Topics (6 lectures)**: Sub- and supercritical bifurcations, Limit cycles, Noise and background turbulence effects
5. **Modeling (9 lectures)**: Linear stability models, Acoustic-combustion coupling, Lumped models-Helmholtz resonators, Well stirred reactors,