16.50 Aerospace Propulsion
Spring 2020 (updated for covid-19 response)

Instructors
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Learning Objectives

1. List and explain the characteristics and performance of aerospace propulsion systems.
2. Model newly-conceived rocket or air breathing propulsion systems and estimate their performance and behavior.
3. Carry out preliminary designs of rocket and air breathing propulsion systems to meet specified requirements.

Measurable Outcomes

1. Identify the source of mass and source of energy for different aerospace propulsion systems.
2. Explain the different features and capabilities of chemical and non-chemical rocket propulsion systems.
3. Explain the choice of rocket based on mission requirements and calculate the mission delta-V for both impulsive and low thrust maneuvers.
4. Calculate the specific impulse and mass flow for a rocket engine with the fluid considered as an ideal gas with constant specific heats.
5. Estimate the specific impulse and mass flow for a rocket engine accounting for chemical reaction and non-constant specific heats.
6. Explain the different subsystems in liquid and solid propellant rockets.
7. Estimate the heat transfer rates in rocket nozzles and in aeroengine turbine components.
8. Explain the different performance metrics, and the corresponding performance limits, for gas turbine aeroengines and link these to the design features.
9. Explain the physical constraints which couple the different components in a gas turbine.
10. Calculate the design thrust and overall efficiency of turbojet and turbofan engines, with and without afterburners, from given component performance.
11. Calculate pressure and temperature changes across the turbomachinery, inlet, and exhaust nozzle in a gas turbine engine from a knowledge of the geometry.

Course syllabus and lecture outline

	Lect.	DATE	TOPICS COVERED
1	JS/CGG	Feb 3, Mon	**Unified view of aerospace propulsion systems.** Motivation. Classification. Fundamentals: thrust, efficiencies.
2	CGG	Feb 5, Wed	**Rocket performance.** Thrust and specific impulse. Rocket equation. Rocket staging.
3	CGG	Feb 10, Mon	**Mission requirements.** Rocket selection by mission. 'Delta-V' calculation. Impulsive maneuvers.
4	CGG	Feb 12, Wed **PSET 1 OUT**	Low thrust maneuvers. Optimum exhaust velocity (non-chemical).
5	CGG	Feb 18, Tue	**Review of Thermodynamics and compressible flows**.
6	CGG	Feb 19, Wed **PSET 1 DUE** **PSET 2 OUT**	**Chemical rockets. Modeling of nozzle flow.** Rocket elements. Nozzle flow. Nozzle area ratio. Thrust coefficient. Characteristic velocity.
7	CGG	Feb 24, Mon	Types of nozzles. Connection of flow to nozzle shape. **+ QUIZ 1**
8	JS	Feb 26, Wed **PSET 2 DUE**	**Solid rockets.** Gas generators. Stability. Grain design.
9	CGG	Mar 2, Mon	**Combustion and reacting flows.** Combustion thermochemistry. Equilibrium flows. Frozen flow.
10	CGG	Mar 4, Wed **PSET 3 OUT**	**Heat transfer and cooling.** Convective, ablative, heat sink and radiation cooling.
11	CGG	Mar 9, Mon	**Liquid rockets.** Pressurization cycles. Turbomachinery.
12	CGG	Mar 11, Wed	**Electric thrusters.** Why electric propulsion. Thrust generation mechanisms.
		Mar 16, Mon	**CLASS CANCELLED**
		Mar 18, Wed	**CLASS CANCELLED**
14	JS	Mar 30, Mon	**Aircraft propulsion mission requirements.**

		PSET 3 DUE **PSET 4 OUT**	Design requirements for passenger aircraft. Structure of the Atmosphere.
15	JS	Apr 1, Wed	Range. Thrust.
16	JS	Apr 6, Mon **PSET 4 DUE** **PSET 5 OUT**	**Gas turbine thermodynamic modeling.** Thermodynamics reminder. Propulsive, thermal, overall efficiencies. Gas turbine principles.
17	JS	Apr 8, Wed	Isentropic efficiency for components. Gas turbine cycles. Thermodynamic analysis.
18	JS	Apr 13, Mon **PSET 5 DUE** **PSET 6 OUT**	**Engine configurations.** Turbojet and turbofan. Turbofan motivation. Bypass ratio.
19	JS	Apr 15, Wed	**Dimensional analysis.**
20	JS	Apr 22, Wed **PSET 6 DUE** **PSET 7 OUT**	**Turbomachinery**. Compressors and turbines. Blade nomenclature. Euler work equation.
21	JS	Apr 27, Mon	Velocity triangles. Performance maps.
22	JS	Apr 29, Wed **PSET 7 DUE** **PSET 8 OUT**	Radial equilibrium theory. Mean-line design and reaction.
23	JS	May 4, Mon	Compressibility effects. Polytropic efficiency.
24	CGG	May 6, Wed **PSET 8 DUE**	**Component matching.** Introduction to component matching. Off-design operation.
25	CGG	May 11, Mon	**Additional components in combat engines.** Design requirements for combat aircraft. Afterburners.