Lecture 42

Review for Final

Final Exam Location and Hours

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Final Exam Search | Fall 2018

Final exam information for 13400
ASE 376K PROPULSION
MAHALINGAM, R

Final Exam	
Date & Time:	FRIDAY, DECEMBER 14, 9-12 N
Location:	MEZ 1.306

Final Exam Info

- Test is Closed book: That means no books, notes, laptops, tablets or phones. Calculators are allowed. No scratch paper. Use the backside of your test booklet.
- Any equations needed that you are not expected to remember are provided.
- Ask for clarification if the meaning of a question is unclear to you.

Key equations

- Mach Number u/a, where u is flight speed and a is speed of sound.
- Speed of sound $a = \sqrt{\gamma RT}$
- Pressure temperature relationship for isentropic flow, P2/P1 = $(T2/T1)^{(\gamma/\gamma-1)}$
- Fuel equivalency ratio = actual fuel flow rate/stoichiometric fuel flow rate
- $Thrust = \dot{m}e * Ue - \dot{m}a * Ua + (Pe - Pa) * Ae$
- TSFC = mdot(fuel)/Thrust
- Isp = Thrust/(mdot(fuel)*g) (Note g = 9.8 m/s^2)
- Flow coefficient = c_z/U = Engine axial velocity/rotor speed
- Stage loading coefficient, $\psi = \Delta h_0/U^2$ = Rotor work/Rotor Velocity squared
- Compressor overall pressure ratio, Pr = $(Pr_{stage})^n$, where n is number of stages.
- Rocket equation $\Delta u = U_{eq} ln(MR), where\ MR = Mo/Mb$
- Specific Power for Electrostatic Ion Engines = P/Melec (W/kg)

Key ideas to remember

- Enthalpy balance across engine:
  - Inlet : KE converted to stagnation enthalpy
  - Compressor: Stgn. Enthalpy increase equals work done on fluid
  - Combustor: Stgn. Enthalpy increase equals heat input
  - Turbine: Stgn. Enthalpy decrease equals work removed from fluid
  - Nozzle: Stgn. Enthalpy converts to KE
- Note: Any other equations outside of these basic equations will be provided on the test.

Start – Test 1

- Speed ranges for different types of propulsion, Mach No.
- Energy transformation processes for different types of engines
- Ideal gas law, non-ideal behavior
- Behavior of Mixtures of Ideal Gases
- Normal shock behavior
- Oblique shock behavior
- P-v and T-s diagrams
- Brayton cycle efficiency, temperature and pressure ratios for maximum power
- Air-breathing engine efficiencies: propulsive, thermal, overall – understand meanings
- Stoichiometric fuel air ratio, fuel-air equivalence ratio
- Meaning and Calculation of Thrust, Specific Impulse, Thrust Specific Fuel Consumption
- Ideal and non-ideal Ramjets, Inlet to Exit Mach number relationships

Test 1-Test 2

- Adiabatic efficiency for diffusers, combustors, nozzles, compressors and turbines using T-S diagrams
- Pressure recovery ratios for diffusers, combustors, nozzles, compressors and turbines using T-S diagrams
- Turbojets: Inlet, Compressor pressure ratios, Thrust, Peak Temperature Issues
- Turbofans: Bypass Ratio, Thrust, Manipulation of thrust equation
- Inlet behavior, Normal and Oblique Shock Inlets – Qualitative Issues, Analysis
- Nozzles – Analysis, thrust vectoring, CD Nozzles
- Combustion chamber basics – fuel-air ratio requirements
- Balancing chemical equations
- Stoichiometric fuel air ratio, fuel-air equivalence ratio
- Chemical emissions – Different contributors

Test 2-Test 3

- Compressor/Turbine physics – reasons for geometric characteristics, how temperature and pressure vary along the length
- Axial vs centrifugal compressors and turbines
- Key differences between compressors and turbines
- Relationship between overall pressure ratio and stage pressure ratio for compressors
- Polytropic efficiency
- **Velocity triangles – how to construct, definitions of angles, α and β**
- Understand Degree of reaction, Mean radius analysis
- Non-dimensional parameters – flow coefficient and work factor are important
- Cooling of turbo-machinery

Test 3-End

- Rocket Propulsion system classifications – advantages and disadvantages of each
- Use conditions/reasons
- Force vs Impulse, specific Impulse for rockets
- Delta-v mission budget
- Rocket equation for Delta-V
- Staging
- Chemical rocket propulsion – thermodynamics, characteristic velocity, thrust coefficient
- Nozzle characteristics – under, over and perfectly expanded
- Electric rocket propulsion, fundamental equation for electrostatic Ion propulsion, comparison with chemical propulsion