AME 436, 2nd Midterm Exam Study Guide
April 5, 2018

Format of the exam

90 minutes allowed. The midterm exam will be open book to the extent of lecture notes, your personal notes, homework sets and solutions and the (optional) textbooks by Heywood, Mattingly and Turns. Laptop computers and tablets are NOT permitted but calculators are. **The exam will be from 6:40 PM to 8:10 PM.** The regular lecture will start at 8:20 PM.

Recommendations for studying

- Redo the example problems in the lecture notes without looking at the answers
- Reconstruct the P-V and T-s diagrams in the lecture notes, *i.e.*, draw them yourself
- Redo the homework problems in the lecture notes without looking at the answers
- Play the Powerpoint files of the lecture notes (including animations, I think those are pretty useful, at least I hope they are considering how much time I put into them…)

Material covered

The exam may cover any material through the end of section on Unsteady Flow engines (i.e. material on Thrust, Compressible Flow, and Airbreathing Propulsion won't be on the exam) but will emphasize material covered since the first midterm, *i.e.* ,Lectures 6 - 10. This material includes:

- Unsteady flow engines
    - Design parameters
        - r_c, V_d, N
    - Performance parameters
        - Indicated and Brake torque, power, MEP
        - Efficiency - thermal, mechanical, volumetric
        - Emissions
    - Ideal-gas cycle analysis
        - KNOW T-S AND P-V DIAGRAMS BACKWARDS AND FORWARDS!
        - Otto and Diesel cycles and variations (e.g. complete expansion)
        - Cycle comparisons
    - Fuel-air cycles
    - Modifications to ideal cycles
        - Slow burn
        - Friction
        - Heat loss
    - Combustion in unsteady flow engines
        - Knock
            - What is it and why is it bad?
            - Effect of fuel type and fuel structure
            - Effect of operating conditions
        - Flammability/misfire limits

"Where can I find worked examples of using P-V and T-s diagrams? There aren't any given in this course!"

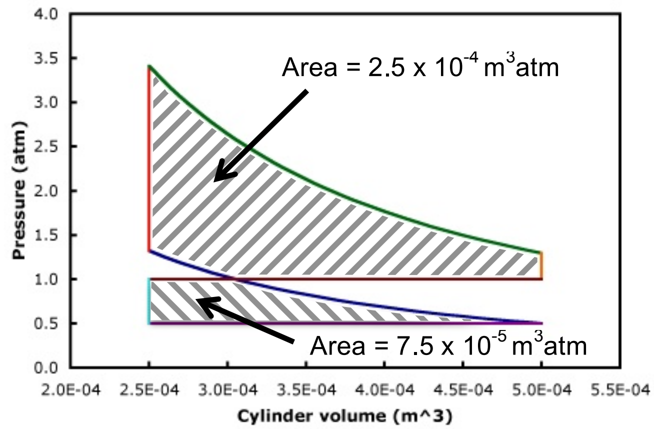
- Lecture 7: p. 19 (1), p. 24 (2), p. 25 (2)
- Lecture 8: p. 8-9 (1), p. 10 – 11 (1), p. 29 – 30 (1), p. 31 – 32 (1), p. 33 – 34 (1), p. 38 – 40 (3)
- Lecture 9: p. 11 – 12 (1), p. 14 – 15 (1), p. 20 – 21 (1), p. 26 – 27 (1), p. 28 – 29 (1), p. 30 – 31 (1), p. 37 – 38 (2)
- Homework #3 (3)
- Homework #4 (3)

TOTAL: 27 worked examples

Midterm exam from 2 years ago (some problems should look familiar) (average was 63/100)

Problem #1 (Ideal engine performance) (30 points total, 5 points each part)

In a engine experiment with rotation rate N = 2400/min, the following P-V plot was measured:



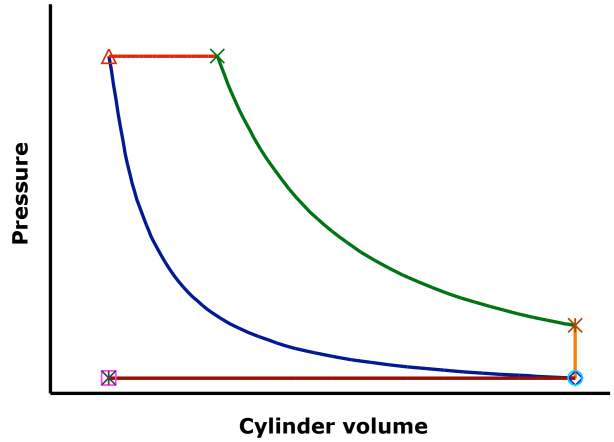
Possibly useful properties: fuel mass fraction f = 0.065; fuel heating value $Q_R = 2.0 \times 10^7$ J/kg; Friction Mean Effective Pressure (FMEP) = 0.5 atm; air density at 1 atm $\rho = 1.18$ kg/m^3; specific heat ratio $\gamma = 1.3$; mixture average molecular mass M = 0.029 kg/mole; units conversion 1 atm = 1.01325×10^5 N/m^2.

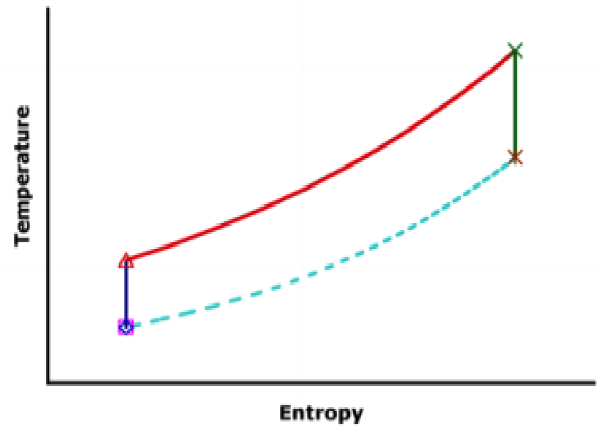
a) What is the Gross Indicated Mean Effective Pressure ($IMEP_g$)?
b) What is the **theoretical maximum** thermal efficiency for this cycle assuming **no heat or friction losses and ignoring the pumping losses**?
c) If the volumetric efficiency is 85%, what is the air mass flow rate ($\dot{m}_{air}$)?
d) What is the heat release (in Joules) for one cycle?
e) What is the net indicated thermal efficiency ($\eta_{th,ind,net}$)?
f) What is the brake power (P_{brake})?

Problem #2 (P-V and T-s diagrams) (40 points total, 5 points each diagram)

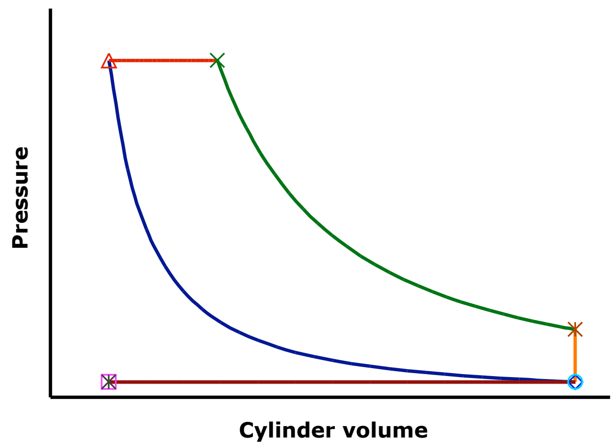
Consider the "baseline" ideal Diesel cycle shown on the P-V and T-s diagrams. Sketch modified P-V and T-s diagrams for the scenarios given. Unless otherwise noted, assume the initial temperature and pressure, compression ratio, fuel mass fraction, heating value, etc. are unchanged. Where useful for clarity, label plots with phrases like "this area = that area," "these two temperatures are the same," etc. In some cases there may be no change. **Unintelligible scribbles don't get much credit!**

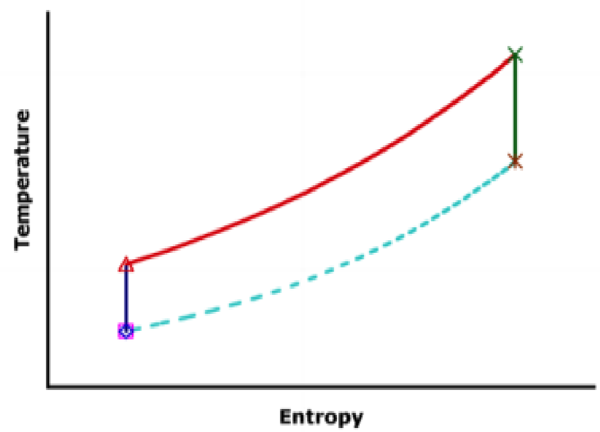
a) The amount of fuel injected is increased by 25% but to avoid overheating, the compression ratio is changed so that the modified cycle has the same maximum temperature as the baseline cycle. The combustion still occurs at constant pressure in the modified cycle.



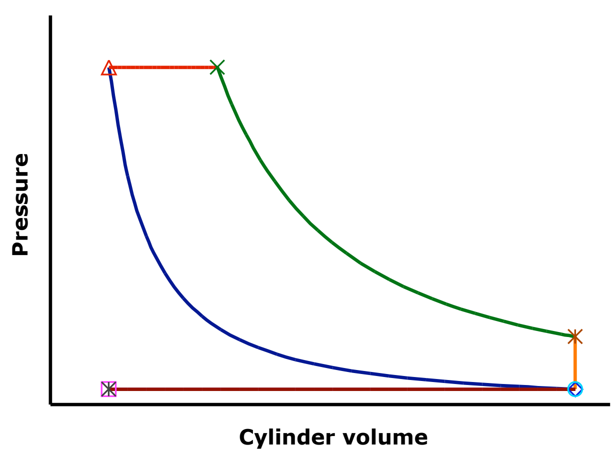


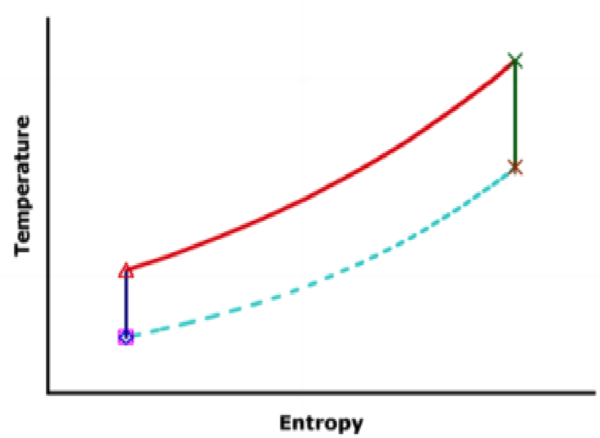
b) There is heat transfer **to the gas** during the compression stroke but not during any other part of the cycle.



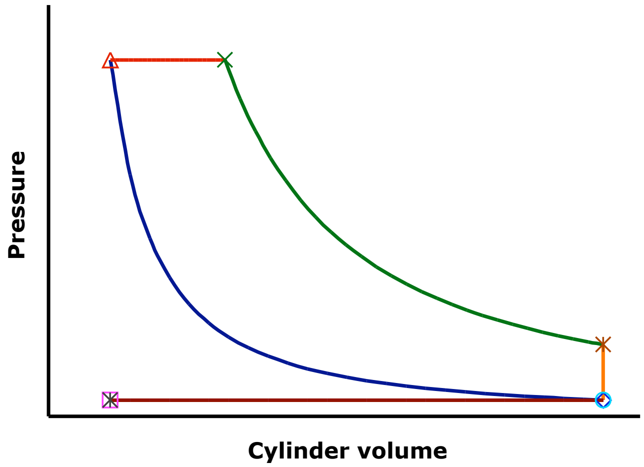


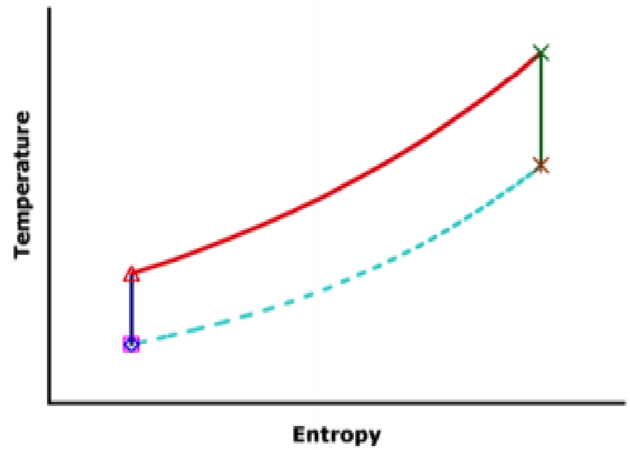
c) The first half the fuel is injected normally and burns at constant pressure, then the fuel injector malfunctions and **the other half of the fuel is injected part way through the expansion process and burns at constant volume**. The total amount of fuel burned is the same as in the baseline cycle.





d) A new lubricant is used that decreases rubbing friction (thus FMEP)





Problem #3 (Non-ideal engine performance) (30 points total, 5 points each part)

Ronney Motors, Inc. claims to have invented a new type of ignition system that **decreases** the time required for a flame to burn in a gasoline-air mixture inside an engine **by a factor of 2**. How would each of the following engine performance parameters be affected by the use of this ignition system, assuming no other properties other than burning time were affected? State in particular would the performance parameter increase, decrease or remain the same, and if there is a change, would it be more than, less than, or exactly a factor of 2. **No credit without explanation!**

(a) Brake thermal efficiency
(b) Pumping Mean Effective Pressure (PMEP)
(c) Fuel mass fraction (f) at the lean misfire limit
(d) Maximum intake temperature without knocking
(e) Nitric oxide (NO) emissions
(f) Unburned hydrocarbon (UHC) emissions