

**AME 436, 2<sup>nd</sup> Midterm Exam Study Guide**  
**April 6, 2016**

**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. 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
    - Incomplete combustion / flame quenching

“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. 22 (1), p. 23 (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. 10 – 11 (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 (4)
- Homework #4 (4)

**TOTAL: 30**

**Last year's midterm exam (some problems should look familiar) (average was 64.2/100)**

**Problem #1 (engine performance) (25 points total)**

Planet X is has an atmosphere exactly the same as on earth except that (1) the ambient pressure is half that of earth and (2) the oxygen mole fraction is 42% compared to 21% on earth. The ambient temperature is 300K on both planets.

Mixture properties  $\gamma = 1.3$ ,  $R = 300 \text{ J/kgK}$ ,  $C_p = 1300 \text{ J/kgK}$ ,  $Q_R(\text{methane}) = 5.0 \times 10^7 \text{ J/kg}$

- (10 points) Estimate the BMEP of stoichiometric premixed-charge naturally-aspirated methane-fueled engines on Planet X at wide-open throttle, with compression ratio 9. Assume volumetric efficiency  $\eta_V = 0.9$  and FMEP = 1 atm.
- (5 points) Estimate the displacement volume ( $V_d$ ) needed to obtain a 100 horsepower two-stroke engine on Planet X assuming a maximum rotation speed  $N = 4000 \text{ rev/min}$ . (1 horsepower = 746 Watts).
- (5 points) Would an engine on Planet X be more or less likely to knock than the same engine (i.e. same compression ratio, displacement volume and rotation rate) on earth burning a stoichiometric methane-air mixture? Or would there be the same tendency to knock in both environments? **No credit without explanation.**
- (5 points) Would an engine on Planet X produce more or less NO than same engine on earth burning a stoichiometric methane + earth air mixture? **No credit without explanation.**

**Problem #2 (15 points total)**

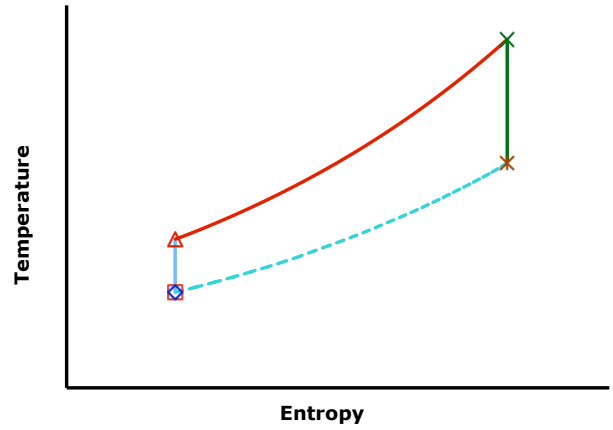
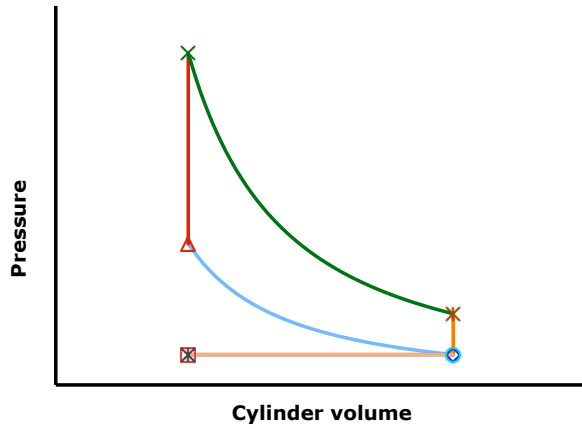
Ronney Oil and Gas Company claims to have developed a fuel, called PDR<sup>®</sup>, that has all the same thermodynamic properties, transport properties, chemical reaction rate parameters, etc. as octane except that PDR<sup>®</sup> has **10% higher heating value per unit mass** than octane. If PDR<sup>®</sup> fuel were used instead of octane, how would each of the following be affected? In particular, state whether each of the above will increase or decrease or remain constant, and by less than 10%, more than, or exactly 10% **and briefly explain why. No credit without explanation.**

- The thermal efficiency of an **ideal** Diesel cycle
- BMEP of a premixed-charge engine burning a stoichiometric mixture
- The equivalence ratio at the lean misfire limit in a premixed-charge engine

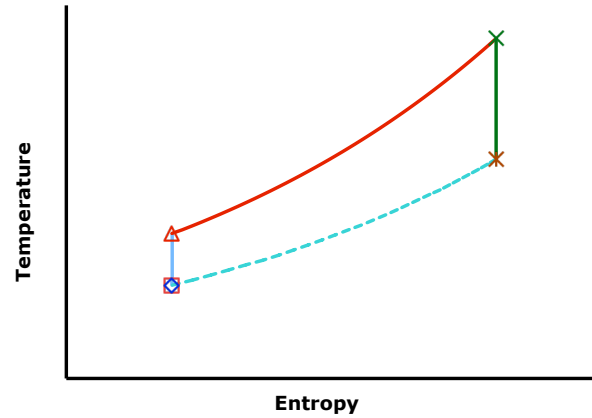
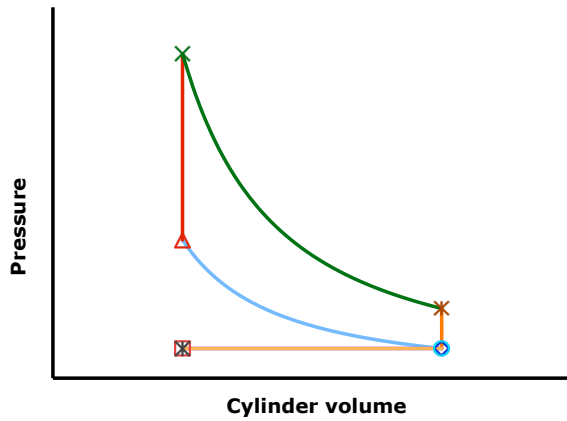
**Problem #3 (30 points total, 5 points each diagram)**

Consider the "baseline" unthrottled ideal Otto cycle 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. **Illegible scribbles don't get much credit!**

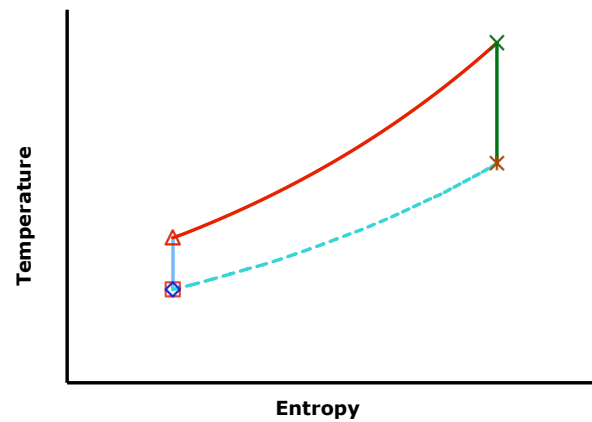
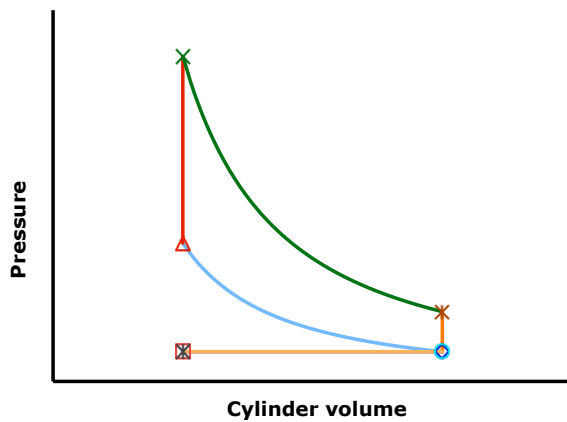
- The cycle is changed to a Diesel cycle with the **same maximum volume and same maximum temperature**. (The compression ratio will need to be changed to accomplish this.)



- b) Due to poor fuel/air mixing, the first half of heat release during combustion occurs at constant pressure. The second half of the combustion process occurs normally at constant volume.



- c) The compression process is irreversible (but still adiabatic) but the rest of the cycle is still ideal.



**Problem #4 (30 points, 5 points each part)**

Two premixed-charge engines, A and B, have the same displacement volume, use the same fuel at the same equivalence ratio and are identical in every other way except:

- Engine A rotates at 1000 RPM and has an intake pressure ( $P_1$ ) of 1 atm (i.e. wide-open throttle, naturally aspirated)
- Engine B rotates at 4000 RPM and has an intake pressure ( $P_1$ ) of 0.5 atm (i.e. a throttled condition)

Explain in a few words which engine, A or B, would have **(no credit without explanation!)**

- a) The higher brake power
- b) The higher BMEP
- c) The higher brake thermal efficiency
- d) The greater tendency to knock
- e) The greater tendency to misfire
- f) The greater CO emissions