AME 436	Assigned: Thursday 2/26/09
Problem Set #3	• **Due Friday 3/6/09 at 4:30 pm in OHE 430J** • **Email to the grader (Thada Suksila, suksila@usc.edu) or fax to 213-740-8071 if you're off campus** • **DEN students submit through the usual channels**

Problem #1 (Cycle analysis) (15 points)

For an ideal Diesel cycle with the following parameters: r = 20, γ = 1.3, M = 0.029 kg/mole, f = 0.05, Q_R = 4.45 x 10^7 J/kg, initial temperature T_2 = 300K, initial pressure P_2 = 1 atm, P_{exh} = 1 atm, h = 0, $\eta_{comp} = \eta_{exp}$ = 1 (in other words, an ideal cycle), determine the following:

a) Temperature (T_3) and pressure (P_3) after compression, and the compression work per kg of mixture
b) Temperature (T_4) and pressure (P_4) after combustion, and the work output during combustion per kg of mixture
c) Cutoff ratio
d) Temperature (T_5) and pressure (P_5) after expansion, and the expansion work per kg of mixture
e) Net work per kg of mixture
f) Thermal efficiency
g) IMEP

You can check your answers with aircycles4recips.xls, but I want to see that you know the equations behind them. For example in part a, $P_3 = P_2r^\gamma = (1\text{ atm})(20)^{1.3}$ = 49.1 atm and $T_3 = T_2r^{\gamma-1} = (300\text{K})(15)^{(1.3-1)}$ = 737K.

Problem #2 (Cycle analysis) (15 points)

For an ideal complete expansion (Atkinson) cycle with the following parameters: r = 20, γ = 1.3, M = 0.029 kg/mole, f = 0.05, Q_R = 4.45 x 10^7 J/kg, initial temperature T_2 = 300K, initial pressure P_2 = 1 atm, P_{exh} = 1 atm, h = 0, $\eta_{comp} = \eta_{exp}$ = 1 (in other words, an ideal cycle), determine the following:

a) Temperature (T_3) and pressure (P_3) after compression, and the compression work per kg of mixture
b) Temperature (T_4) and pressure (P_4) after combustion, and the work output during combustion per kg of mixture
c) Temperature (T_5) and pressure (P_5) after expansion, and the expansion work per kg of mixture
d) Net work per kg of mixture
e) Thermal efficiency
f) IMEP

Again you can check your answers with aircycles4recips.xls, but I want to see that you know the equations behind them.

Problem #3 (Cycle analysis) (15 points)

a) Repeat Problem 1 using a fuel-air cycle analysis (using GASEQ, as outline in the Lecture 7 notes) with an iso-octane air mixture.
b) Explain why the peak temperature, work done and efficiency are all lower for the fuel-air cycle as compared to the air cycle analysis of Problem 1. (Remember, GASEQ is a adiabatic equilibrium solver; it doesn't compute the effects of slow burn, heat loss or friction.)

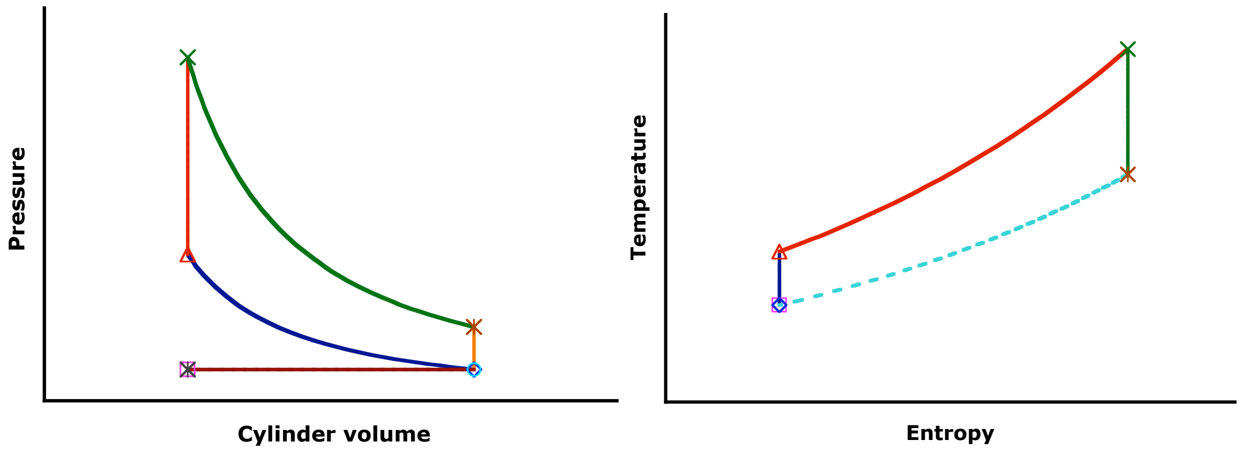
<u>Problem #4 (P-v and T-s diagrams)</u> (30 points) (from last year's midterm exam)

Consider the "baseline" ideal Otto cycle shown on the P-V and T-s diagrams (next page). Sketch modified P-V and T-s diagrams if

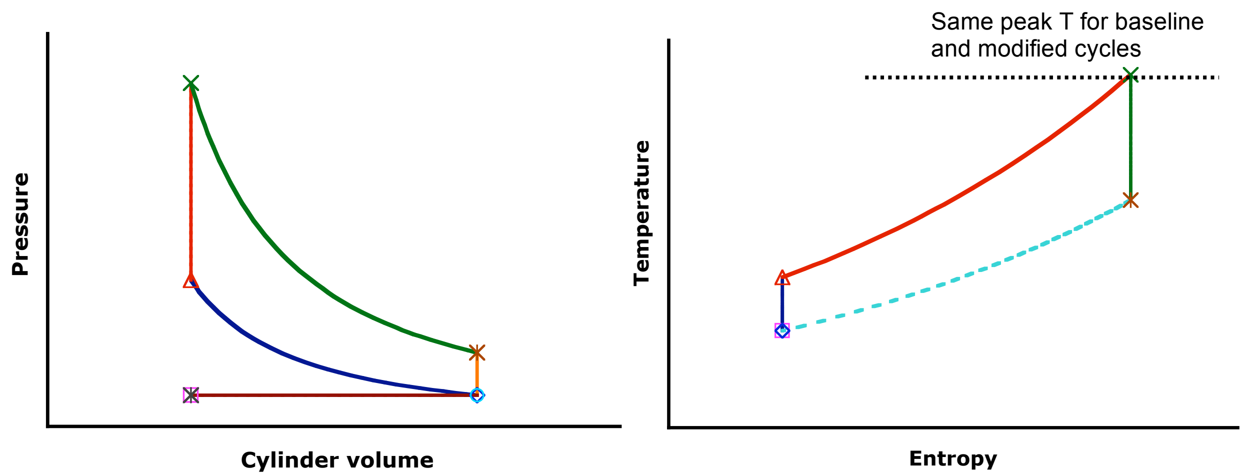
a) Knocking occurs and all of the fuel-air mixture burns instantaneously before the piston reaches Top Dead Center (minimum cylinder volume)
b) A new fuel with 10% higher heating value is used (fuel mass fraction not changed), but to avoid overheating the engine, the compression ratio is changed so that *the peak temperature is the same for the baseline cycle and the modified cycle.*
c) The vehicle drives into a dense fog where the air contains much more moisture, thus C_V increases and γ decreases.

Unless otherwise noted, assume in each case 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 to the P-V or T-s diagram.* **Unintelligible scribbles on P-V and T-s diagrams don't get much credit!**

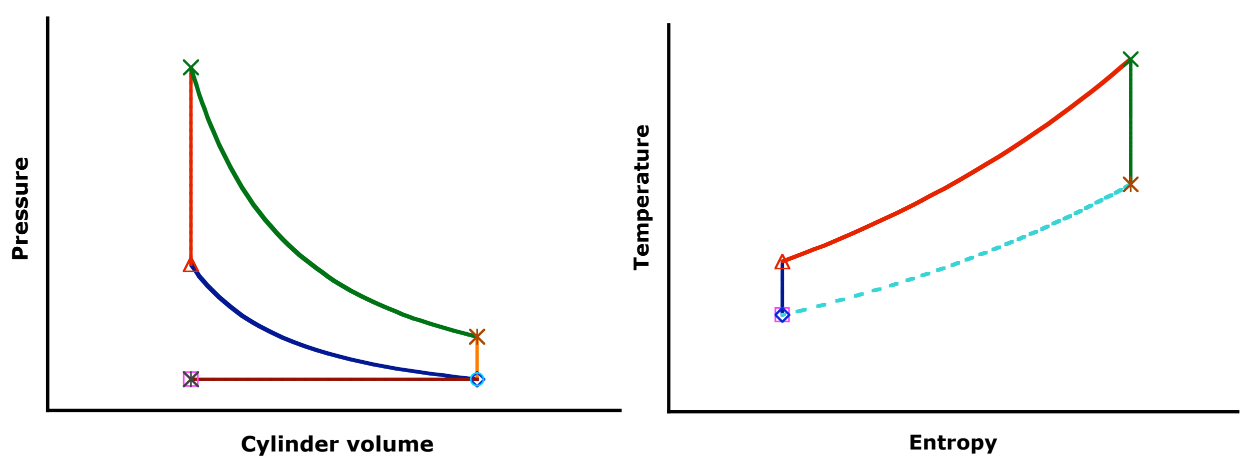
a)


Pressure
Cylinder volume
Temperature
Entropy

b)


Pressure
Cylinder volume
Same peak T for baseline
and modified cycles
Temperature
Entropy

c)


Pressure
Cylinder volume
Temperature
Entropy

Problem #5 (10 points) (from last year's midterm exam)

Ronney Oil and Gas Company claims to have developed a fuel, called PDR®, that has all the same thermodynamic properties, transport properties, chemical reaction rate parameters, etc. as octane except that PDR® has **10% higher heating value per unit mass** than octane. If PDR® 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.**

a) The thermal efficiency of an **ideal** Diesel cycle

b) BMEP of a premixed-charge engine burning a stoichiometric mixture

Problem #6 (Miscellaneous) (5 points) (from last year's final exam)

On Planet X the constant-pressure specific heats (C_p) of air and all other gases are 10% **higher** than they are on earth. All other properties of the atmosphere are exactly the same as on earth, in particular the mole-based ideal gas constant ($\mathfrak{R}$), molecular weight (M), thermal conductivity (k), density (ρ), mole fraction of O_2 in the atmosphere, etc. In particular, state whether each of these properties will be higher, lower or the same on Planet X, and if different, by less than, more than, or exactly a factor of 10%.

a) Brake thermal efficiency of a nonpremixed-charge engine

Problem #7 General cycle knowledge (10 points) (from last year's final exam)

Answer the following questions (T-s diagrams will be much appreciated…)

a) Why do internal combustion engines need to compress the air or fuel-air mixture before burning? What would happen if there were no compression, could work still be generated?

b) Why is it necessary to add heat to generate work?