AME 436	**Assigned: Friday 3/4/2016**
Problem Set #3	• Due Monday 3/21/2016 at 4:30 pm in drop-off box in OHE 430N (back room of the OHE 430 suite of offices, where the Xerox machine is located) • Hard copies are preferred but you can email your assignment to the graders at ame436usc@gmail.com if you're off campus. Emailed files must be a single .pdf file, not 10 or 20 .jpg images! • DEN students submit through the usual channels.

Problem #1 (Cycle analysis) (20 points)

For an ideal Otto cycle with the following parameters: r = 10, $\gamma = 1.4$, M = 0.029 kg/mole, f = 0.05, $Q_R = 4.45 \times 10^7$ J/kg, initial temperature $T_2 = 300$K, initial pressure $P_2 = 0.4$ atm, $P_{exh} = 1$ atm, h = 0, $\eta_{comp} = \eta_{exp} = 1$ (in other words, an ideal cycle), determine the following:

(You can check your answers with aircycles4recips.xls, but show the equations and numbers you used. For example in part (a), $P_3 = P_2 r^{\gamma}$ = (0.4 atm)$(10)^{1.4}$ = 10.05 atm and $T_3 = T_2 r^{\gamma-1}$= (300K)$(10)^{(1.4-1)}$ = 754K.)

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 (gross indicated work – pumping work)
e) Thermal Efficiency
f) Net IMEP

Problem #2 (Cycle analysis) (20 points)

For an ideal complete expansion cycle with the following parameters: $r_e = 30$, $\gamma = 1.4$, M = 0.029 kg/mole, f = 0.05, $Q_R = 4.45 \times 10^7$ J/kg, initial temperature $T_2 = 300$K, 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:

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

a) Compression Ratio (r_c)
b) Temperature (T_3) and pressure (P_3) after compression, and the compression work per kg of mixture
c) Temperature (T_4) and pressure (P_4) after combustion, and the work output during combustion per kg of mixture
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) Net IMEP

Problem #3 (Cycle analysis) (20 points)

a) Repeat Problem 2 using a fuel-air cycle analysis (using GASEQ, as outline in the Lecture 8 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 2. (Remember, GASEQ is a adiabatic equilibrium solver; it doesn't compute or account for non-ideal effects such as slow burn, heat loss or friction.)

Problem #4 (to be continued on HW #4) (10 points)

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 $\gamma = 1.3$, $R = 300$ J/kgK, $C_P = 1300$ J/kgK, Q_R(methane) $= 5.0 \times 10^7$ J/kg

a) Calculate the stoichiometric fuel mass fraction (f) of methane burning on Planet X.

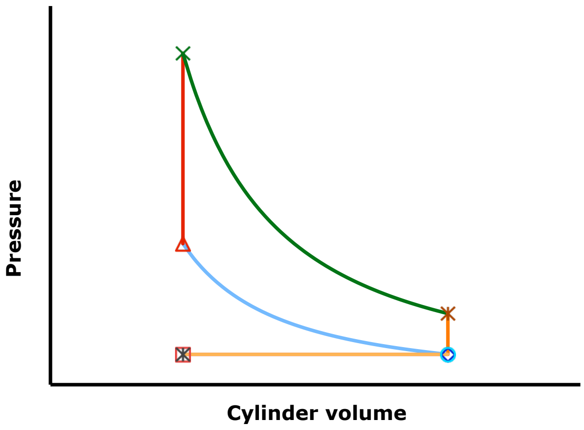
b) Estimate the BMEP of stoichiometric premixed-charge naturally-aspirated methane-fueled engines on Planet X at wide-open throttle, with compression ratio 9. Assume volumetric efficiency $\eta_V = 0.9$ and FMEP = 1 atm.

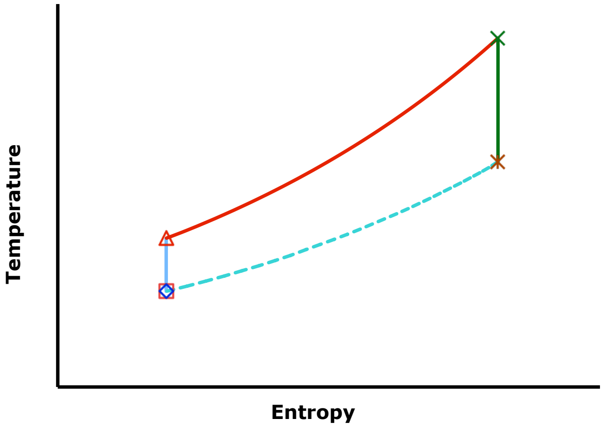
c) Estimate the displacement volume (V_d) needed to obtain a 100 horsepower two-stroke engine on Planet X assuming a maximum rotation speed N = 4000 rev/min. (1 horsepower = 746 Watts).

Problem #5 (P-V and T-s diagrams) (25 points total)

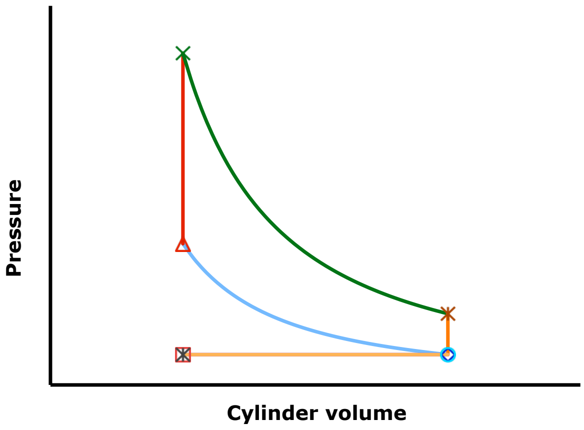
Consider the "baseline" unthrottled ideal Otto cycle P-V and T-s diagrams. Sketch modified P-V and T-s diagrams for the scenarios given. Unless otherwise noted, assume the initial temperature and pressure, compression ratio, fuel mass fraction, heating value, etc. are unchanged. Where useful for clarity, label plots with phrases like "this area = that area," "these two temperatures are the same," etc. **Illegible scribbles don't get much credit!**

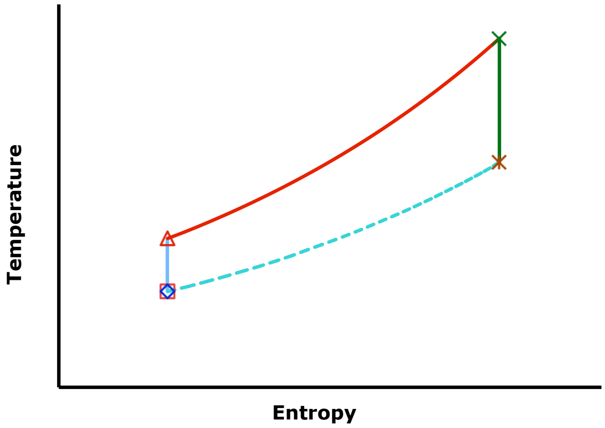
a) The engine is changed to a complete-expansion (Atkinson) cycle with **the same maximum volume and same maximum pressure**



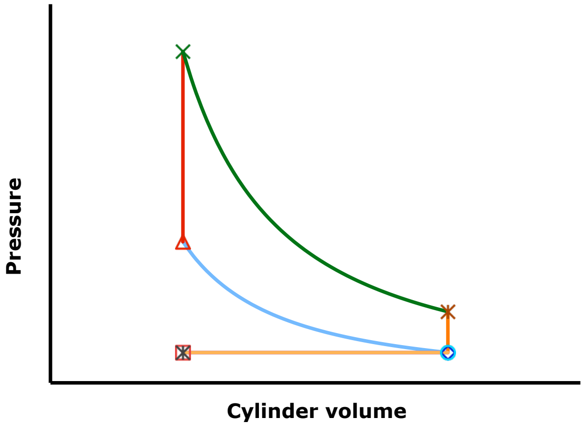


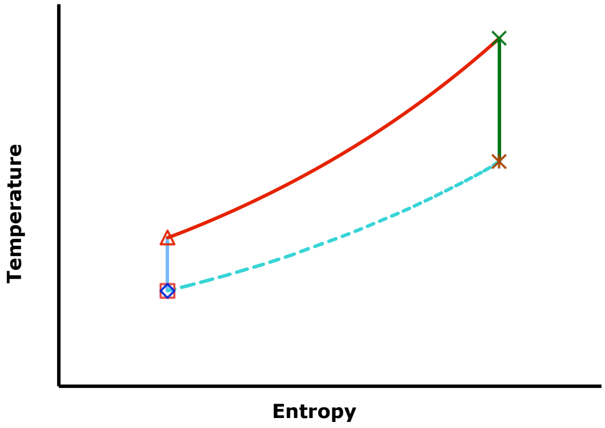
b) The engine is supercharged but the compression ratio is decreased so that the maximum pressure is the same as the baseline cycle. The maximum volume is the same for both cycles.



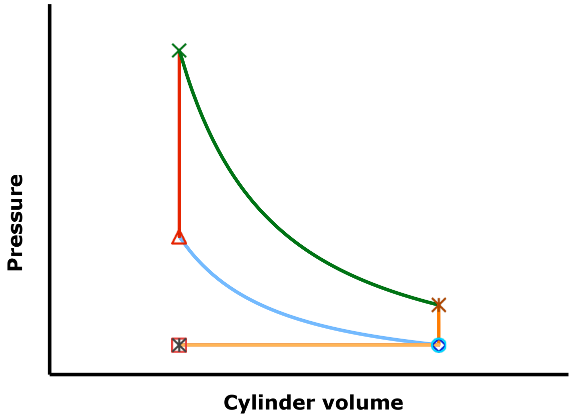


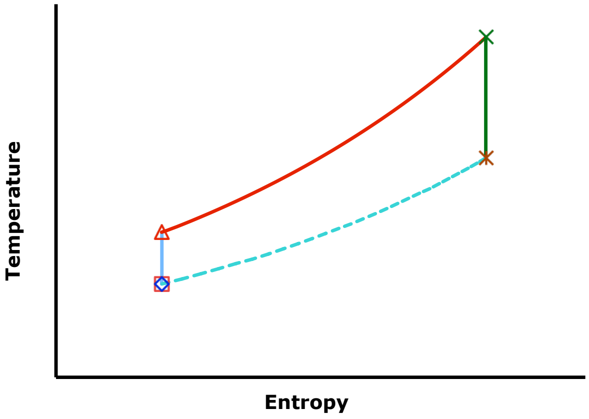
c) The cycle is changed to a Diesel cycle with the **same maximum volume and same maximum temperature**. (The compression ratio will need to be changed to accomplish this.)





d) 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.





Problem #6 (5 points)

For each of the cycle modifications in problem 5, will the brake thermal efficiency increase, decrease or remain the same? Explain briefly.