AME 436	Assigned: Friday 3/26/2016
Problem Set #4	• Due Friday 4/1/2016 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.

For all problems you can use the AirCycles.xls spreadsheet to guide your answers but you need to explain your results. Laptops or smartphones running Excel spreadsheets will NOT be permitted on the exams.

Problem #1 (20 points)

For a Diesel cycle with constant-pressure combustion and the following parameters: $r = 20$, $\gamma = 1.3$, $M = 0.029$ kg/mole, $f = 0.05$, $Q_R = 4.0 \times 10^7$ J/kg, $T_2 = 300$K, $P_2 = 1$ atm, $P_{exh} = 1$ atm, $h = 0$, $\eta_{comp} = \eta_{exp} = 0.9$ (in other words, ideal **except for the compression and expansion efficiency**), 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) after combustion and work output during combustion per kg of mixture
c) Cutoff ratio (β)
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 (don't forget the work during combustion since $dV \neq 0$)
f) Thermal Efficiency
g) IMEP

Problem #2 (continuation of problem #4 from HW #3) (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) = 5.0×10^7 J/kg

a) 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.**
b) 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.**

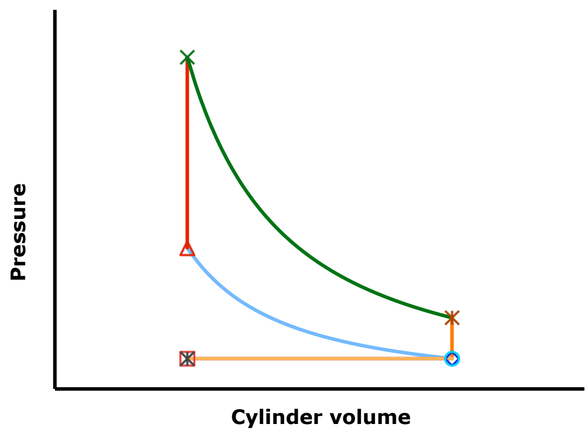
Problem #3 (10 points)

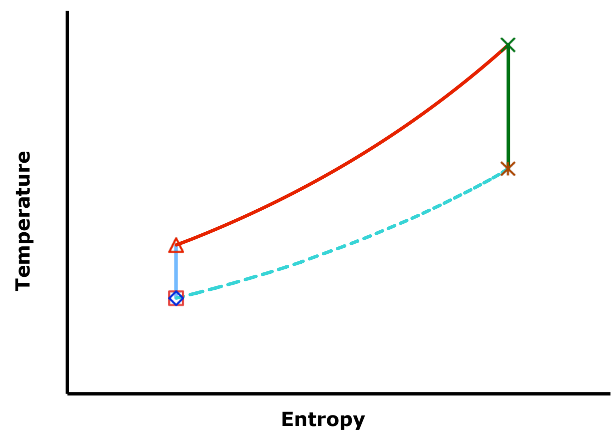
Ronney Oil and Gas Company claims to have developed a fuel, called PDR®, that has all the same thermodynamic properties, transport properties, chemical reaction rate parameters, etc. as octane except that PDR® has **10% higher heating value per unit mass** than octane. If PDR® fuel were used instead 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. No credit without explanation.**

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

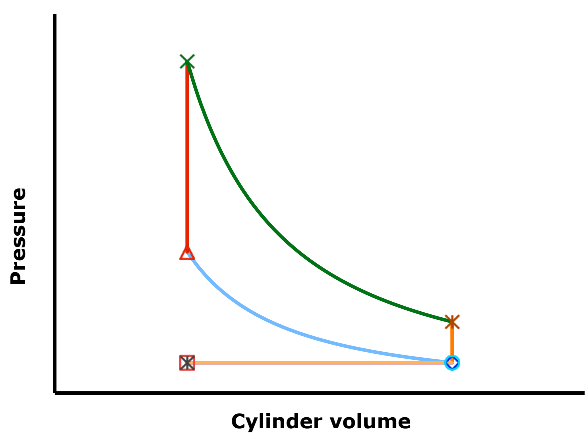
Problem #4 (20 points)

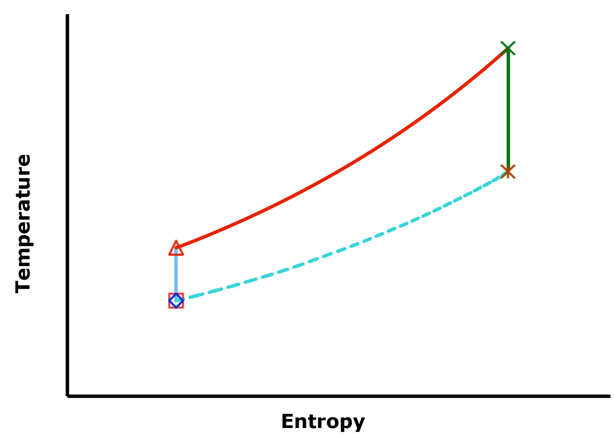
Consider the "baseline" ideal Otto cycle shown on the P-V and T-s diagrams. Sketch modified P-V and T-s diagrams if the following changes are made. Unless otherwise noted, assume in each case the initial temperature and pressure, compression ratio, fuel mass fraction, heating value, etc. are unchanged. 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.



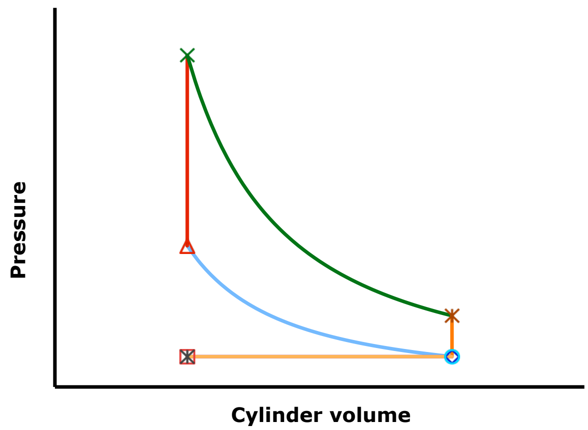


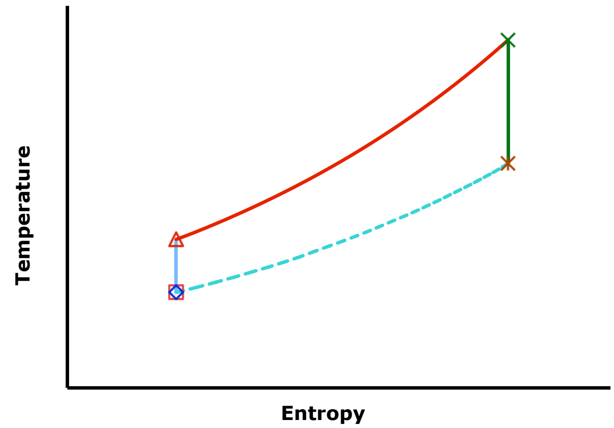
a) There is heat loss during the constant-volume combustion but **not during any other part of the cycle**.





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





c) The engine is taken to Planet Y, which has exactly the same fuel and atmosphere as earth but the specific heat ratio (γ) is lower on Planet Y. The compression ratio is increased so that the peak pressure is the same on earth as on Planet Y.

<u>Problem #5</u> (5 points)

For parts (a) - (c) in problem 4, will the change to the cycle cause the brake thermal efficiency to increase, decrease or remain the same? Explain briefly.

<u>Problem #6 (20 points)</u>

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

<u>Problem #7 (15 points)</u>

Evaluate the claims made in this article:

http://www.technologyreview.com/news/417918/ultra-efficient-gas-engine-passes-test/?nlid=2798&a=f

In particular state:

a) Is gasoline a good fuel to use for compression ignition? Why or why not?
b) Is it possible that heating the fuel will make the mixture burn faster? Why or why not?
c) If the mixture burns fast enough, can the efficiency be increased by 50%? Why or why not?
d) Would partially oxidizing the fuel (assume this happens before injecting it into the cylinder, though the article doesn't say where the partial oxidation occurs) increase efficiency? Why or why not?

e) Is it possible for the engine in a typical small passenger vehicle (which normally gets say 35 mpg) to be improved to yield 98 mpg? Why or why not?

f) Find one significant factual errors in **the first paragraph** of this page from TransonicCombustion's website: http://www.tscombustion.com/autoinefficiency.html (Actually that page on company's website doesn't exist anymore, but there's an archived copy at: http://web.archive.org/web/20120227045036/http://www.tscombustion.com/autoinefficiency.html)