Homework Assignment #2

1. **Engine Components Lab**

   Answer questions associated with the Engine Components Lab activity.
   These are identified with bold notes.

2. **Engine Design and Operating Parameters**

   Search the web, manufacturing literature, or technical papers/articles to which you may have access in order to find the following specifications for a **naturally aspirated** engine of personal interest. <u>Identify your source, acquire the information below, and report this in your homework.</u> Discuss the consistency between the data for your engine and the values shown in Table 1.3. Also discuss any issues you encountered in gathering this information.
   - bore, stroke, and displacement
   - dry weight
   - compression ratio
   - engine type (SI or Diesel)
   - engine class/application (from Table 1.3)
   - type of cooling
   - number of revolutions per power stroke
   - power (at a maximum speed)
   - maximum torque (at a specific speed)
   - torque or power versus speed at full throttle (if available)

3. **Physical Intuition about Engine Processes**

   Several velocity, time, and length scales are useful in understanding what goes on inside engines. Make estimates of the following quantities for a 1.6 liter four-cylinder spark-ignition engine with a bore of 100 mm, operating at wide-open throttle at 2500 rev/min. Clearly document your assumptions and your solution process.
   a) The time occupied by one engine operating cycle, the intake process, the compression process, the combustion process, the expansion process, and the exhaust process.
   b) The average charge velocity in the intake port during the induction process assuming that the port area is about 20 percent of the piston area.
   c) The average velocity which the flame travels across the combustion chamber.
   d) The length of the intake system (intake port, manifold runner, etc.) which is filled by one cylinder charge just before the intake valve opens and the charge enters the cylinder.
   e) The length of exhaust system filled by one cylinder charge after it exits the cylinder assuming an average exhaust gas temperature of 425 C.

4. **Air/Fuel Ratio Analysis**

Methanol (CH_3OH) is combusted with air (composed of 21% oxygen and 79% nitrogen). That means for every mol of O_2 there are 3.76 mols of N_2. Assume that combustion is complete and occurs under stoichiometric conditions (e.g. the only products of this reaction are CO_2, H_2), and N_2).

a) Write a balanced reaction for stoichiometric methanol/air combustion.

b) What is the air/fuel ratio for stoichiometric methanol/air combustion on a <u>molar basis?</u>

c) What is the air/fuel ratio for stoichiometric methanol/air combustion on a <u>mass basis?</u> Carbon has a molar mass of 12g/mol. The hydrogen atom has a molar mass of 1 g/mol. The oxygen atom has a molar mass of 16 g/mol. The nitrogen atom has a molar mass of 14 g/mol.

d) For methane (CH_4) the stoichiometric air/fuel ratio is ~17:1 on a mass basis. For an engine with fixed displacement operating under stoichiometric conditions at atmospheric pressure, would you expect the mass flow rate of methanol to be larger or smaller than methane in the same engine (same compression ratio, engine speed, inlet conditions, equivalence ratio)? Why?

5. **Cycle Modeling**

Develop an EES model that predicts all of the variables in the array table for the Diesel Cycle in HW #1. Use your model to calculate heat transfer and work transfer for each process as well as the entire cycle. Compute the cycle efficiency and plot this over a range of cut-off ratios between 1.5 and 2.5. Make appropriate assumptions, clearly identifying these in your documentation. Explain trends shown in your data and compare your results with those from the Diesel Cycle efficiency equation that assumes constant specific heat.