TFES Lab (ME EN 4650)
Spark Ignition Engine

Required Figures

A meaningful and comprehensive figure caption must accompany all figures. The figure caption must include the following label: Figure 1X. where X denotes the letter a – e according to the order listed below. For this lab, use the figure captions in the Word template that has been provided for you (see the CANVAS assignment).

1a. Plot the measured crankshaft torque (τ) versus crankshaft engine speed (ω). Plot torque on the y-axis in units of N·m and speed on the x-axis in units of RPM. Use a black open circles for the data points. Do NOT connect the circles with a line.

1b. On a single figure, plot the measured brake power ($\dot{W}_b$) and the total mechanical power ($\dot{W}_b + \dot{W}_f$) versus crankshaft engine speed (ω), compared to the net work ($\dot{W}_{\text{net}}$) of an *ideal* engine operating under the same conditions. Plot power on the y-axis in units of kW and speed on the x-axis in units of RPM. Use the following linestyles: ○ $\dot{W}_b$; □ $\dot{W}_b + \dot{W}_f$; — $\dot{W}_{\text{net}}$. Do NOT connect the data markers with a line. Include a legend.

1c. On a single figure, plot the measured thermal efficiency (η_{th}) and measured mechanical efficiency (η_{mech}) versus crankshaft engine speed (ω), compared to that of an ideal engine (η_{Otto}) operating under the same conditions. Plot efficiency on the y-axis in terms of a percent, and speed on the x-axis in units of RPM. Use the following linestyles: ○ η_{mech}; □ η_{th}; — η_{Otto}. Do NOT connect the data markers with a line. Include a legend.

1d. On a single figure, plot the work rate terms in the energy balance (**??**) versus crankshaft engine speed (ω) for the data only. Plot the work rate terms on the y-axis in units of kW, and the speed on x-axis in units of RPM. Use the following linestyles: ○ $\dot{E}_{\text{in}}$; ◇ $\dot{W}_b$; □ $\dot{Q}$; × $\dot{W}_f$. Do NOT connect the markers with a line. Include a legend.

1e. Plot the mean effective pressure (MEP) versus crankshaft engine speed (ω). Plot pressure on the y-axis in units of kPa and speed on the x-axis in units of RPM. Use black open circles (○) for the data. Do NOT connect the circles with a line. Linearly interpolate your data to estimate the value of MEP at 2600 RPM; plot that single data point using a black plus sign (+).

Short-Answer Questions

Your responses to the questions below must be typed and organized in the order listed below with the correct numbering scheme. Responses must be concise, clear, and written in complete sentences with correct grammar/sentence structure. Points will be deducted for poor writing. In all cases, your responses must reflect the results you obtained from your plots, unless you explain otherwise.

2a. State the value of the following energy ratios (in terms of a percentage) averaged over the entire range of engine speeds examined: $\dot{W}_b/\dot{E}_{\text{in}}$, $\dot{W}_f/\dot{E}_{\text{in}}$, and $\dot{Q}/\dot{E}_{\text{in}}$. Discuss how the frictional/inertial loss compares to the miscellaneous heat lost to the surroundings, and how this affects the overall thermal efficiency of the engine. [2–4 sentences]

2b. Write one sentence for each of the items below related to engine efficiency. [3 sentences total]

→ State the average mechanical efficiency of the engine (averaged over the range of crankshaft speeds measured), and compare this value with the typical mechanical efficiency of an *electric motor* having an equivalent power rating (1–2 hp).

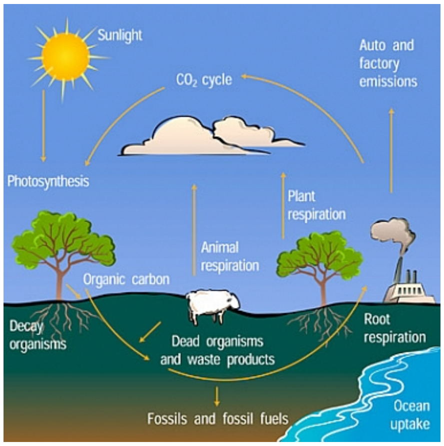
→ Write a statement that compares the calculated thermal efficiency with that of an ideal Otto cycle, by quantifying the discrepancy (ϵ) with a percentage, as follows

$$\epsilon = \frac{\eta_{\text{Otto}} - \eta_{\text{th}}}{\eta_{\text{Otto}}} \cdot 100 \, .$$

→ State three things that were neglected in the ideal model of the Otto cycle that might contribute to such a discrepancy.

2c. Based on your calculations for the mean effective pressure (MEP), estimate the average force acting on the piston head during the cycle when the engine is operating at 2600 RPM. State your answer in units of both N and lbs. Include this calculation in your Matlab code and have the code display the result to the screen. [1 sentence]

2d. Carbon dioxide (CO_2), a greenhouse gas, is released into the environment from the exhaust of spark ignition engines. A diagram of the carbon lifecycle is shown below, illustrating how auto emissions tend to alter the natural balance by creating excessive carbon dioxide in the atmosphere. Spend some time to research (using the internet, textbooks, or other sources) solutions for reducing CO_2 gas emissions from combustion engines. For example, some technologies can help increase engine efficiency, thereby reducing CO_2 emissions. State one operation or hardware modification that could be implemented to improve the efficiency of a spark ignition engine, such as turbo-charging, inner cooling, split-fire spark plugs, variable valve timing, etc. Explain how this modification works to improve engine efficiency and describe some of the challenges associated with implementing this modification in practice. [4–6 sentences plus at least one reference]


Sunlight
CO_2 cycle
Auto and factory emissions
Photosynthesis
Plant respiration
Animal respiration
Organic carbon
Decay organisms
Dead organisms and waste products
Root respiration
Fossils and fossil fuels
Ocean uptake