Programming exercise D: Knocking analysis

Introduction:

Knocking as it appears in the pressure measurements seems like random pressure fluctuations. However, when these pressure fluctuations are analyzed in the frequency domain it become obvious that they are systematic and linked to the acoustic properties of the combustion chamber and the gas temperature.

In present programming exercise you are supposed to carry out a spectral analysis of pressure fluctuations from strong knocking measured in a HCCI engine. The engine had a pancake shaped combustion chamber and Dimethyl ether (DME) was used as fuel.

Data:

Database:
The relevant measurements are contained in the **Matlab example package** from exercise C.
Pressure data:
Should be treated as programming exercise A, but the resolution is 0.1 CAD and there is 20 cycles in every recording.
Engine data:
Strokes per cycle = 4
Bore: 85 mm
Stroke: 85 mm
Connecting rod length: 160 mm
Gas data:
Heat capacity ratio (or isentropic expansion factor) $\gamma = 1.35$

Task:

Pick the measurements made with N = 1200 rpm and a torque of 21.3 Nm. This is the only one you will use so don't bother with the other ones.

The first column in the pressure files contains data from the pressure pickup.

The pickup signals comes in [Volt] and is converted into [bar] with a gain of 9. You may assume atmospheric pressure around -180 CAD.

Use a single, representative pressure curve when you make spectral analysis of the knocking.

Subtract a low pass filtered pressure curve from the unfiltered curve to get a knock curve. Use the knock curve to find the resonance frequencies. Use the uploaded Matlab function **fftBPfilter.m** to filter the data.

Plot the unfiltered and the low pass filtered pressure curve in the same plot to evaluate if the cut off frequency and the cut off steepness was well chosen.

Use the uploaded Matlab function **FFTanalyze.m** to find the spectrum of the knock curve in the interval from 0 to 10 CAD.

Find the theory for calculating resonance frequencies in the article:
http://www.lth.se/fileadmin/lth/student/Maskinteknik/Filer/Examensarbete/Lundin_Vressner.pdf

For calculating the theoretical resonance frequencies, you will need the gas temperature. You can use your function from exercise B to estimate the gas temperature by assuming 21 °C in the intake.

Plot the frequency spectrum and compare the measured frequency peaks with theoretically calculated resonance frequencies. It is best illustrative with the theoretical resonance frequencies as vertical lines of different colors and a legend in the same plot as the spectrum.