Important information regarding MECH 447/652 assignments

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1 Introduction

This year's Combustion class, we are planing to integrate a design project along the semester to anchor your combustion knowledge in concrete examples. The assignments of the semester will be organised as follow:

- [bonus points] Project 0 - Software installation
- [20%] Project 1 - Combustion thermodynamics
- [20%] Project 2 - Reactors
- [20%] Project 3 - 1D Flames
- [20%] Design Project

MECH 652 students will have a workload ∼25% greater than for MECH 447 students. Each project and exam will have an extra exercise for MECH 652 students, which can be done by MECH447 students to gain bonus points.

2 Projects

There will be 3 projects given during the semester, each requiring few weeks to complete. They will each count for 20% of your final grade. You will have a possibility to accumulate bonus point in each project, if you choose to answer the bonus questions. **You are advised to begin each as soon as you receive them.** They require a lot of work and programming that can not be achieved in only a few hours before the deadline. **Any late submission will lead to point penalty, -20 points per day.**

In this course, exercises need to be done using Cantera, a combustion software. It is based on Python, and can be used with Spyder or Jupyter Notebook, two types of compilers. You will have the choice to use the one you prefer. Unfortunately, you can not use Cantera through Matlab as it does not contain every package we will need in this course. You will have to complete a first project, P0, to ensure that you can install the software, as well as understand the language used, and solve basic problems, leading to bonus points.

In the projects, you will have to program the combustion problems in Python language, and to produce graphs and data to answer the project questions. The assignment will be submitted as a pdf file, produced using the processor of your choice (Latex, Word, PowerPoint...), containing only the graphs and the answers to the questions. Please, **do not include the code you used to process the results**.

Each graph and answer to a question must be done with an analysis. For example, "*the adiabatic temperature of a hydrogen flame is greater than for an ethane flame*", explain why, how are different effects related, what are the mechanisms at play, analyse the trends of the curves, interpret the results, explain a potential impact on your conclusion, etc. Points will be given for the quality of the report. Please be concise in your explanations, use bullet points and avoid long sentences and paragraphs. Another example of an answer: "*the adiabatic temperature of a hydrogen flame is greater than for an ethane flame. This is caused by:*

- *the absence of C in hydrogen → reduce the heat absorbed in the carbon breakdown*
- *the absence of CO and CO_2 in the products → reduce the absorbed heat from high Cp-molecules*
- *the reduced air to fuel ratio required for complete combustion → less N2 available to absorb heat*

After grading each project, I will return an evaluation grid to know exactly where you obtained points. I will not provide a general solution to the project. It is your responsibility to try solving the exercise, however, you can ask me for guidance, and to check your result.

We highly encourage you to help each other out, however, plagiarism will not be tolerated. To guide you through the exercises, I often add references to some online examples: `https://cantera.org/examples/index.html`. You have the right to use the code given online, simply adapt it to your needs, and more importantly, **understand what you are using and copying**!

If you are stuck on programming, check out Cantera's documentation: `https://cantera.org/documentation/`, **do not contact me for help unless you have already searched online.** I will only answer if you have searched on your own and can provide me with examples of what you have tried to solve your issue. You can also get some useful help from the Cantera users forum: `https://groups.google.com/g/cantera-users`

Finally, compare your results with what you know, and the literature. Do your results make sense? Are they similar to what you can find in the lecture notes, or in textbooks? Few textbooks to open:

- Turns - An Introduction to Combustion Concepts and Applications - McGraw Hill - 2012
- Law - Combustion Physics - Cambridge University Press - 2006
- Lefebvre - Gas Turbine, Alternative Fuels and Emissions - 2010

3 Design project

The design project will consist in designing[1] a thermal engine to produce energy. You will have to form groups of 3, composed of a mix of graduate and undergraduate students. Each group will be choosing their own design constraints:

- **fuel** - fossil fuels, biogas, hydrogen, ... anything as long as it is available on Cantera[2]
- **application** - transportation (rocket, car, boat, plane...), industry, ...
- **output energy required** - choose something that makes sense with the application you are choosing

The list is non exhaustive, and you are free to choose anything that interests you.

By using each project as an example, you will be able to run your simulation for the fuel specific to your project. Thus, I would advise you to apply each assignment to your own fuel as a side-project to advance your work for the end of the semester.

At the end of the semester, you will give an oral presentation of your system ($\sim$ 20-25min). Overall, we will want to know:

- What energy do you need to produce? Can you reach this value? If so, does it require combustion technologies[3]?
- What is the cycling requirement of the energy?
- How much fuel+oxidizer do you need?
- What is the size of the combustion chamber for safety?

[1] When I say design, I do not expect you to draw the system with CAD. Here, we are just trying to have a rough idea, with first hand calculation of what the system could look like.

[2] this may require a change to thermochemical models, further discussion with me is needed

[3] RQL, EGR, blends, dilution, ...

- What are the pollutants generated? How can you mitigate them to remain under the government threshold?
- Overall, is it feasible (fuel availability, materials, pollutants, economics, required space, safety ...)?
- Would you choose another fuel/application rather than the one you developed?
- What major difficulty did you encounter in the project?

The group composition, the choice of the alternative fuel, and the date of presentation will be set mid-semester.

Each group will be asked to do a mid-project presentation (~ 5 min.), about 3 weeks after the creation of the groups to ensure that every group is up to speed with the project and clarify expectations.

No written reports are expected.

To differentiate the grading between graduate and undergraduate students, the graduate students will also have to prepare an extra 20 minutes lecture around the design project they will be presenting, related to combustion. It should be an in-depth presentation of a topic, such as a new technology, a challenge in combustion, a lack of understanding in a domain...

4 Office hours

Contact: Marie Meulemans - marie.meulemans@mcgill.ca

I am available by email for any question related to the projects, the design project, the lecture notes, and exams. I will only answer during appropriate working hours, allow a delay of 24h for me to get back to you.

I will be organising office hours 1 to 2 weeks before each project deadline and exam, and will let you know of the location and date few days prior to it.

I will not help you solve a programming error if you have not proven to me that you have tried to fix it yourself using Google or classmates.