Class Assignments

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Abstract. Courses assignment due for the final exam. This document summarizes the assignments due for the final exam of the class "Computational Techniques for Thermochemical Propulsion" (051176). A brief report (about 4-5 pages) has to be sumbitted for each "minor" part. The report of the final assignment is expected to contain a more thorough description of procedures and results (around 15-20 pages).

Main points of the report must be:

1. Brief description of the problem: geometry, underlying physics, quantities of interest.
2. Description of the relevant setup parameters: algorithm settings, boundary conditions, numerical schemes (if relevant), etc.
3. Brief description of the mesh;
4. Description of the post-processing setup;
5. Convergence: residual history and convergence of at least 1 physical quantity of choice;
6. Other results, as requested;

If the assignment consists in a "baseline" case and modifications to it, it is not necessary to repeat in the report the common setup between base and modified case. However, unless explicitly stated, results from baseline and modified cases must be compared.

If the case is unsteady, please use appropriate statistics to report time-varying data.

How to sumbit

For each assignment, the following files have to be sumbitted:

- the report in PDF format
- the working case setup (i.e. the case solver with '0','constant' and 'system' folders) for the baseline case and its variants (**do NOT include results**).
- the log file of the solution.

All files must be compressed in an archive named after its author:

`SurnameName.tgz`

IMPORTANT NOTE: a SINGLE tar archive (`nameSurname.tgz`) must be uploaded via fileSender (`https://filesender.polimi.it/index.php?s=upload`) at least 5 days before the day of the oral examination.

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1 Incompressible Flow - `Lab02`

Test matrix:

1. Baseline case (steady-state solver), $U = 10$ m/s, $U_f = 15$ m/s
2. Unsteady version of the baseline, with $CFL \leq 20$
3. As above, but with $CFL \leq 1$

Quantities to be extracted:

- Velocity profile along a transverse line located at $y = 100$ mm;
- Total drag force on the V-shaped component;
- Visualization of the velocity field in the whole domain;
- Max and min values of y^+

2 Heat Transfer - `Lab04`

Test matrix:

1. Baseline case: Boussinesq-based solver, $T_f = 350$ K, $U = 10$ m/s, $U_f = 15$ m/s, adiabatic walls, $CFL \leq 5$
2. As in point **??**, but with $T_f = 700$ K and $T_{\text{walls}} = 1500$ K
3. Repeat points **??** and **??** with $U = 100$ m/s, $U_f = 150$ m/s
4. Repeat point **??**, but with first-order convection scheme for T

Quantities to be extracted:

- Velocity and temperature profiles along a transverse line at $y = 100$ mm

3 Compressible flow - `Lab04 (part b)`

Test matrix:

1. Baseline case: compressible unsteady solver, $T_f = 350$ K, $U = 10$ m/s, $U_f = 15$ m/s, adiabatic walls, $CFL \leq 5$
2. As in point **??**, but with $T_f = 700$ K and $T_{\text{walls}} = 1500$ K
3. Repeat points **??** and **??** with $U = 100$ m/s, $U_f = 150$ m/s

Quantities to be extracted:

- Velocity and temperature profiles along a transverse line at $y = 100$ mm.
- Compare results with those obtained in Assignment **??**
- Contour plot of Mach number over the whole domain

4 Lagrangian particles tracking & wall-film modeling - `Lab05` and `Lab06`

Common setup: Injector is located at $x = 0$, $y = -0.295$ and points towards positive y direction. 100 mg of n-heptane (C_7H_{16}) are injected over 0.1 s according to a half-sine curve.

→ for simplicity, Wall film is considered on the side walls only.

Test matrix:

1. Baseline case: compressible solver with lagrangian tracking and wall-film modeling. Same setup as the baseline case in Assignment **??**. Consider breakup (ReitzKHRT) and phase change.
2. Same as point #**??** but with ReitzDiwakar breakup model
3. Same as point #**??** but with $T_{\text{inlet}} = 450$ K

Quantities to extract:

- Penetration of spray (95% liquid) over time
- Height of wall film at $t = [0.02, 0.05, 0.08]$ s
- Histogram of particle diameters at $t = [0.02, 0.05, 0.08]$ s
- Contours of fuel vapor at $t = [0.02, 0.05, 0.08]$ s

5 Reacting flows - `Lab07`

Run the case outlined in Assignment **??**, without wall-film modeling but activating n-Heptane combustion.

Hints:

- Temperature must be sufficiently high to ignite fuel. Run a preliminary case with $T_{inlet} = 900$ K;
- Do not inject methane (fuel_inlet is closed);
- n-Heptane combustion reaction is already in the tutorial;
- combustion occurs between air and fuel vapours.

Quantities to extract: at $t = [0.02, 0.05, 0.08]$ s

- Contour plot of temperature
- Isoline at stoichiometric Air/Fuel ratio

6 Final assignment

The final assignment case is a 3D simulation of the combustor examined so far. Consider the same setup used in Assignment **??** and study combustion of n-heptane. Use the skills learned so far to extract a physically and technically meaningful set of information from the results: use the most appropriate post-processing techniques and statistics to reduce the final data. Both numerical and physical convergence of the solution in time has to be shown. If the case is intrinsically unsteady, such a behavior should clearly stem from your report.

The case can be simulated without wall film. Including the (evaporating) wall film may grant extra points.

Minimum set of quantities to extract: at $t = [0.02, 0.05, 0.08]$:

- Visualization of the main flow features (velocity, temperature, vortices, etc.) using the preferred method.
- Isosurface at stoichiometric Air/Fuel ratio.
- Average pressure and temperature at inlet and outlet over time.