Middle East Technical University
Department of Mechanical Engineering
ME489: Applied Scientific Computing
Homework 1

Fall 25

Due Date: October 17, 09.00

You will write a summary of a research article in LaTeX. For this purpose, you can use the "article" document class. Articles are listed below, and you will read and summarize the specific article according to the last digit of your student ID, e.g. if your ID is 21xxx7, you will read the article in item "6-7". This is an individual assignment, and you will upload the PDF and `.tex` files in ODTUCLASS.

In your summary, you should include

1. an abstract section summarizing the main points highlighted in the paper,
2. multiple mathematical expressions
3. at least one standalone figure and multiple figures on the same line using `subfigure` environment.
4. at least one table with proper caption.
5. a reference section using "bibtex" to reference the paper.

All the environments should be properly **cross-referenced**. There is an example below the articles. If you cannot find any of the items above try to copy the one in the example report.

List of Articles

- 0-1: Arndt, D., Bangerth, W., Davydov, D., Heister, T., Heltai, L., Kronbichler, M., Maier, M., Pelteret, J.P., Turcksin, B. and Wells, D., 2021. The deal.II finite element library: Design, features, and insights. Computers & Mathematics with Applications, 81, pp.407-422.
  doi: doi.org/10.1016/j.camwa.2020.02.022

- 2-3: Fischer, P., Kerkemeier, S., Min, M., Lan, Y.H., Phillips, M., Rathnayake, T., Merzari, E., Tomboulides, A., Karakus, A., Chalmers, N. and Warburton, T., 2022. NekRS, a GPU-accelerated spectral element Navier–Stokes solver. Parallel Computing, 114, p.102982.
  doi: doi.org/10.1016/j.parco.2022.102982

- 4-5: Krais, N., Beck, A., Bolemann, T., Frank, H., Flad, D., Gassner, G., Hindenlang, F., Hoffmann, M., Kuhn, T., Sonntag, M. and Munz, C.D., 2021. FLEXI: A high-order discontinuous Galerkin framework for hyperbolic–parabolic conservation laws. Computers & Mathematics with Applications, 81, pp.186-219.
  doi: doi.org/10.1016/j.camwa.2020.05.004

- 6-7: Krause, M. J., Kummerländer, A., Avis, S. J., Kusumaatmaja, H., Dapelo, D., Klemens, F., ... & Simonis, S., 2021. OpenLB–Open source lattice Boltzmann code. Computers & Mathematics with Applications, 81, pp.258-288..
  doi: doi.org/10.1016/j.camwa.2020.04.033

- 8-9: Anderson, R., Andrej, J., Barker, A., Bramwell, J., Camier, J.S., Cerveny, J., Dobrev, V., Dudouit, Y., Fisher, A., Kolev, T. and Pazner, W., 2021. MFEM: A modular finite element methods library. Computers & Mathematics with Applications, 81, pp.42-74.
  doi: doi.org/10.1016/j.camwa.2020.06.009

Abstract

This is how you cite a paper $\longrightarrow$ In Ranocha et al. [1]
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consectetuer id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo. Cras viverra metus rhoncus sem. Nulla et lectus vestibulum urna fringilla ultrices. Phasellus eu tellus sit amet tortor gravida placerat. Integer sapien est, iaculis in, pretium quis, viverra ac, nunc. Praesent eget sem vel leo ultrices bibendum. Aenean faucibus. Morbi dolor nulla, malesuada eu, pulvinar at, mollis ac, nulla. Curabitur auctor semper nulla. Donec varius orci eget risus. Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. Duis eget orci sit amet orci dignissim rutrum. Nulla malesuada porttitor diam. Donec felis erat, congue non, volutpat at, tincidunt tristique, libero. Vivamus viverra fermentum felis. Donec nonummy pellentesque ante. Phasellus adipiscing semper elit. Proin fermentum massa ac quam. Sed diam turpis, molestie vitae, placerat a, molestie nec, leo. Maecenas lacinia. Nam ipsum ligula, eleifend at, accumsan nec, suscipit a, ipsum. Morbi blandit ligula feugiat magna. Nunc eleifend consequat lorem. Sed lacinia nulla vitae enim. Pellentesque tincidunt purus vel magna. Integer non enim. Praesent euismod nunc eu purus. Donec bibendum quam in tellus. Nullam cursus pulvinar lectus. Donec et mi. Nam vulputate metus eu enim. Vestibulum pellentesque felis eu massa.

You will write a brief summary here. Do not get lost in the details, but learn the basics of the paper. An example of mathematical expression can be seen in Equation 1.

$$\frac{\partial u}{\partial t} + \frac{\partial f}{\partial x} = g \quad x \in \Omega, \tag{1}$$

where $f(u)$ is the flux, $g(x,t)$ is some prescribed forcing function. See also Equations 2 and 3.

$$\begin{aligned} \|f - \mathcal{I}_N f\|_\infty &= \|f - f^* + \mathcal{I}_N f - \mathcal{I}_N f^*\|_\infty \\ &\leq \|f - f^*\|_\infty + \|\mathcal{I}_N\|_\infty \|f - f^*\|_\infty \\ &\leq (1 + \|\mathcal{I}_N\|_\infty) \|f - f^*\|_\infty \end{aligned} \tag{2}$$

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_m \end{bmatrix} = \sigma \left(\begin{bmatrix} w_{1,1} & w_{1,2} & \dots & w_{1,n} \\ w_{2,1} & w_{2,2} & \dots & w_{2,n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{m,1} & w_{m,2} & \dots & w_{m,n} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix} + \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_m \end{bmatrix} \right) \tag{3}$$

For figures, include a standalone figure as in Figure 1. Notice the figure has a detailed caption. Also, include a figure similar to the Figure 2. Learn positioning the subfigures.
Include a table from the paper for practicing table formatting. See Table 1 for an example.

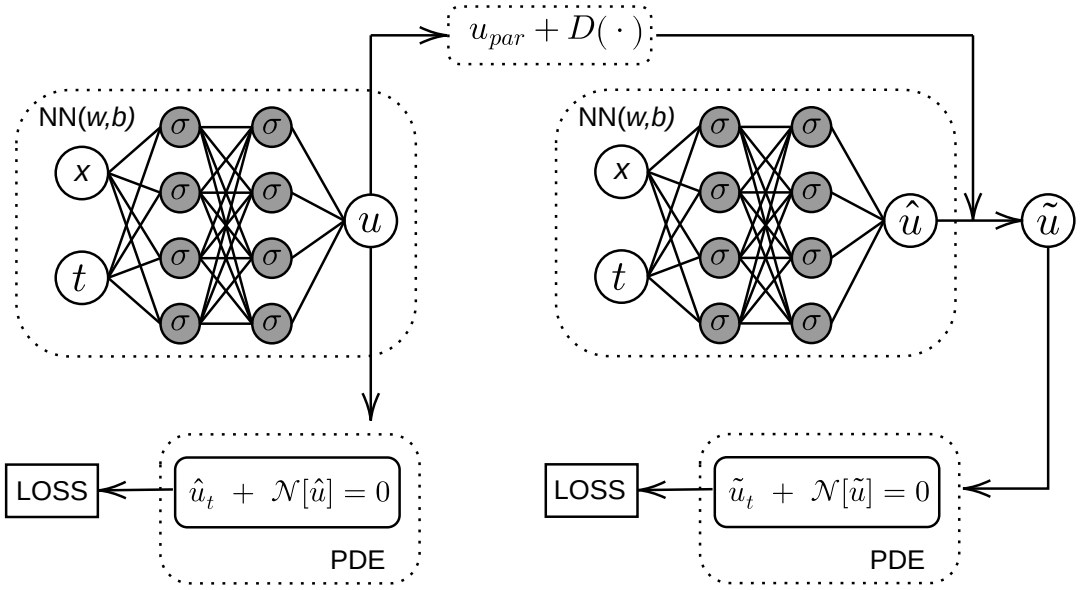
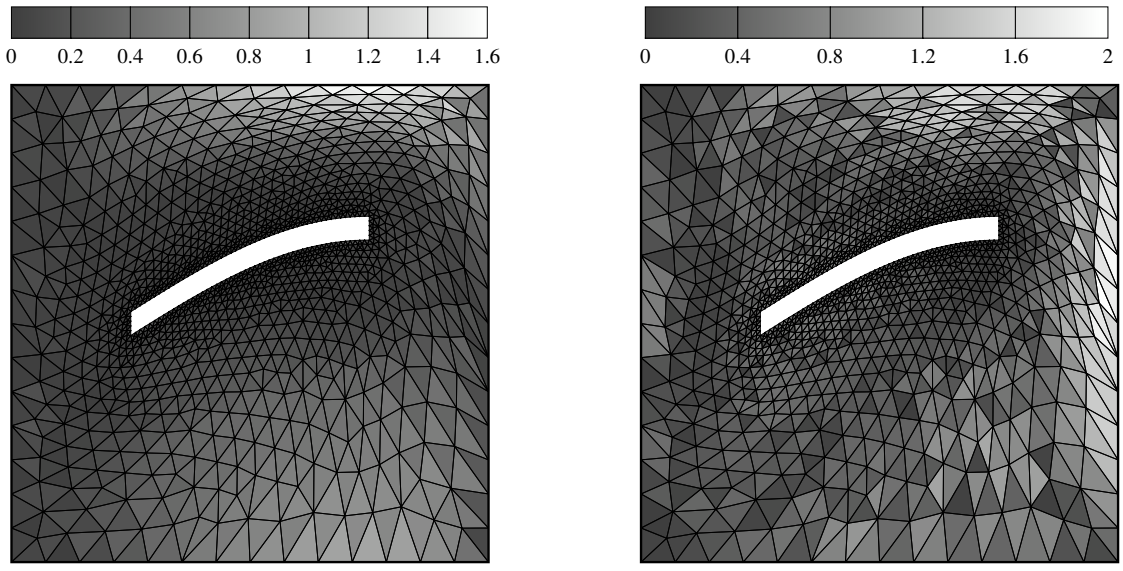


Figure 1: Schematic of PINN approach with exact boundary enforcement. The first PINN on the left shows the original formulation with weakly enforced Dirichlet boundary conditions. The second network uses the particular solution with exact boundary enforcement to satisfy Dirichlet boundaries exactly.



(a) Area change

(b) Shape change

Figure 2: Element quality metrics when the structure tip moves to $y = 4$.

Table 1: Maximum and minimum velocities along the center lines with different weight ratios of residual loss and the boundary loss.

w_R/w_{BC}	$Ra = 10^3$		$Ra = 10^4$		$Ra = 10^5$	
	u_{max}	v_{max}	u_{max}	v_{max}	u_{max}	v_{max}
0.5	0.137	0.138	0.190	0.231	0.137	0.273
1			0.192	0.233	0.128	0.258
2					0.132	0.261
4					0.130	0.261

References

[1] H. Ranocha, M. Schlottke-Lakemper, A. R. Winters, E. Faulhaber, J. Chan, and G. J. Gassner, "Adaptive numerical simulations with Trixi. jl: A case study of Julia for scientific computing," *arXiv preprint arXiv:2108.06476*, 2021.