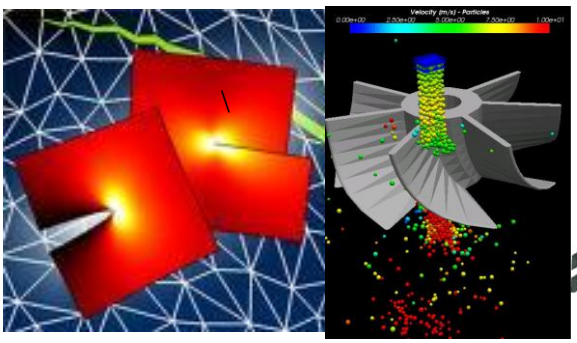
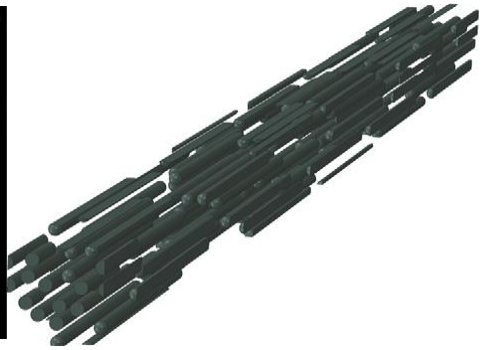
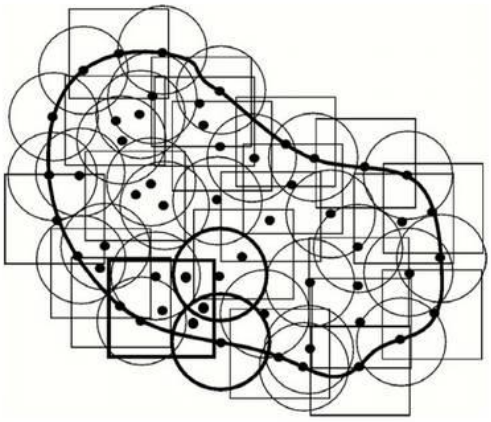
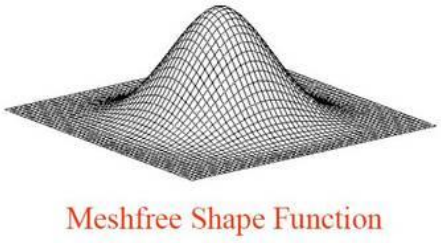
New methods in computational mechanics (MECA0470-1)

Group project: Presentation of an emerging method









Maarten Arnst, Eric Béchet, Ludovic Noels

Academic year 2024-2025

LIÈGE université

Assignment

Each group of 2 students will prepare a presentation on an emerging method in computational mechanics. In particular, it is required to respect the instructions A to D.

A/ Presentation:

This consists in an oral talk with the slides as written support:

- The language will be English ;
- The presentation will hold 30 minutes followed by 15 minutes of questions ;
- Both ppt et pdf versions of the slides will be sent electronically ;
- A printed version of the slides will be the written report.

B/ Content:

The talk will cover the following content

- Introduction of the method
  - Goal
  - Key ideas
  - Brief state of the art study
- Main equations and demonstrations related to the method
  - The ones required for a good understanding will be presented
  - The other ones can be in appendix
- The method will be illustrated by an implementation
  - The method has to be implemented on a simple exemplified problem
  - The source code has to be sent electronically
- Limits/drawbacks of the method
  - Inherent to the method
  - Not solved yet
- Perspectives
  - Which applications?

C/ Resources:

The project will be conducted based on a literature study

- Some key references are provided
- A bibliographic study can be done using http://scholar.google.be/, www.scopus.com
  - Directly accessible from ULiège
  - Require VPN outside ULiège

D/ Deadline:

- Report and code (sent electronically): 9th of May 2025 (to be confirmed)
- Presentation: 15th of May 2025 at 2pm (to be confirmed)

Group 1: The virtual element method for elliptic problems

- Blanca Ayuso de Dios, Konstantin Lipnikov and Gianmarco Manzini (2016) "The nonconforming virtual element method", ESAIM: M2AN, 50 3 (2016) 879-904, https://doi.org/10.1051/m2an/2015090, https://www.esaim-m2an.org/articles/m2an/pdf/2016/03/m2an150085.pdf
- L. Beirão da Veiga, F. Brezzi, L. D. Marini and A. Russo (2014) "Virtual Element Method for general second-order elliptic problems on polygonal meshes", Mathematical Models and Methods in Applied Sciences, Vol. 26, No. 04, pp. 729-750, https://doi.org/10.1142/S0218202516500160, https://arxiv.org/pdf/1412.2646.pdf
- Arun L. Gain, Cameron Talischi, and Glaucio H. Paulino (2014), "On the Virtual Element Method for three-dimensional linear elasticity problems on arbitrary polyhedral meshes", Computer Methods in Applied Mechanics and Engineering, Volume 282, 132-160, https://doi.org/10.1016/j.cma.2014.05.005, http://www.sciencedirect.com/science/article/pii/S0045782514001509
- Andrea Cangiani, Gianmarco Manzini, and Oliver J. Sutton (2017), "Conforming and nonconforming virtual element methods for elliptic problems", IMA Journal of Numerical Analysis, Volume 37, Issue 3, Pages 1317–1354, https://doi.org/10.1093/imanum/drw036, https://academic.oup.com/imajna/article-pdf/37/3/1317/18524063/drw036.pdf
- E.Artioli, L. Beirão da Veiga, C. Lovadina, and E. Sacco. (2017), "Arbitrary order 2D virtual elements for polygonal meshes: part I, elastic problem". Comput Mech 60, 355–377, https://doi.org/10.1007/s00466-017-1404-5, https://link.springer.com/content/pdf/10.1007/s00466-017-1404-5.pdf
- Make an appointment with Eric Béchet, Ludovic Noels

Group 2: Mean zero artificial diffusion (MZAD) for diffusive equations

- Soheil Firooz, B. Daya Reddy, Vasily Zaburdaev, Paul Steinmann (2024), Mean zero artificial diffusion for stable finite element approximation of convection in cellular aggregate formation, Computer Methods in Applied Mechanics and Engineering, Volume 419, 116649, https://doi.org/10.1016/j.cma.2023.116649 , https://www.sciencedirect.com/science/article/pii/S0045782523007727
- Make an appointment Ludovic Noels

Group 3: Lie Group & Quantum Computing

- National Academies of Sciences, and Medicine, *Quantum Computing: Progress and Prospects*. The National Academies Press: Washington, DC, 2019; p 272, https://doi.org/10.17226/25196
- Make an appointment with Françoise Remacle (fremacle@uliege.be), Ludovic Noels

Group 4: Generation of micro-structure of sheet moulding compound (smc) with Voronoi cells

- https://cadxfem.org/vorosweep/
- Johannes Görthofer, Nils Meyer, Tarkes Dora Pallicity, Ludwig Schöttl, Anna Trauth, Malte Schemmann, Martin Hohberg, Pascal Pinter, Peter Elsner, Frank Henning, Andrew Hrymak, Thomas Seelig, Kay Weidenmann, Luise Kärger, Thomas Böhlke, Virtual process chain of sheet molding compound: Development, validation and

perspectives, Composites Part B: Engineering, Volume 169, 2019, Pages 133-147, https://doi.org/10.1016/j.compositesb.2019.04.001, https://www.sciencedirect.com/science/article/pii/S1359836818342963

- Luca M. Martulli, Leen Muyshondt, Martin Kerschbaum, Soraia Pimenta, Stepan V. Lomov, Yentl Swolfs, Carbon fibre sheet moulding compounds with high in-mould flow: Linking morphology to tensile and compressive properties, Composites Part A: Applied Science and Manufacturing, Volume 126, 2019, 105600, https://doi.org/10.1016/j.compositesa.2019.105600
- Hyoung Jun Lim, Hoil Choi, Gun Jin Yun, Multiscale failure and damage analysis of sheet molding compound (SMC) composites using Micro-CT image-based reconstruction model, Composites Part B: Engineering, Volume 231, 2022, 109593, https://doi.org/10.1016/j.compositesb.2021.109593.
- Make an appointment with Eric Béchet, Ludovic Noels

Group 5: Generalized HCT triangle for arbitrary continuity

- Moitinho de Almeida JP. Two families of two-dimensional finite element interpolation functions of general degree with general continuity. Int J Numer Methods Eng. 2023;124(10):2171-2195. doi: https://doi.org/10.1002/nme.7205
- Make an appointment with Éric Béchet

Group 6: Computation exploiting GPU architecture

- M. Leinhauser et al. Metrics and Design of an Instruction Roofline Model for AMD GPUs. ACM Transactions on Parallel Computing. 9:1-14, 2022. https://doi.org/10.1145/350528
- Content
  - Implementation of a computational physics operation on GPU, e.g. FE assembly, sparse matrix-vector product, …
  - Learn about the roofline model approach to performance evaluation, i.e. memory bandwidth vs instruction intensity.
  - Construct a roofline model for one or more GPU systems, and use it to evaluate the performance of the implemented computational physics operation.
  - Carry out final computations on either Lumi (AMD GPU) or Lucia (Nvidia GPU) supercomputers.
- Contact: maarten.arnst@uliege.be and romin.tomasetti@uiliege.be