Solving Partial Differential Equations in Python

— *Finite element methods and FEniCS programming* —

Beijing Institute for Scientific and Engineering Computing (BISEC)
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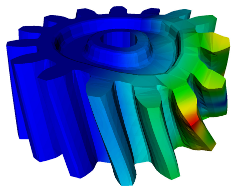
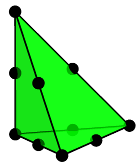
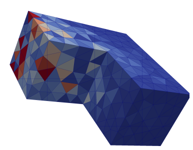


The course gives an introduction to finite element methods and programming of finite element methods for the solution of a large selection of partial differential equations, ranging from simple static linear problems to systems of time-dependent nonlinear problems. Topics include finite element discretization, higher-order discretizations, linear and nonlinear problems, saddle-point problems (the Stokes problem), imcompressible Navier–Stokes equations, static and dynamic hyperelasticity, discontinuous Galerkin methods, a posteriori error estimation and adaptivity, optimal control (adjoint methods), as well as introduction to efficient Python programming for computational science.

The course will be based on the free/open-source software FEniCS for automated solution of differential equations in Python (and C++). FEniCS has a powerful set of features and allows finite element variational problems to be specified in near-mathematical notation directly as part of a Python program. For example, the variational problem for the Poisson equation,

$$\int_\Omega \operatorname{grad} u \cdot \operatorname{grad} v \,\mathrm{d}x = \int_\Omega f v \,\mathrm{d}x \quad \forall v \in V, \tag{1}$$

can be directly translated to the following FEniCS program:

Python code

```
u = TrialFunction(V)
v = TestFunction(V)

a = dot(grad(u), grad(v))*dx
L = f*v*dx
```

Variational problems like the one above may be solved automatically in FEniCS:

Python code

```
u = Function(V)
solve(a == L, u)
```

Other key features of FEniCS include high-performance linear algebra, automatic adaptive mesh refinement, postprocessing, and support for a wide range of finite element function spaces, including high-order spaces and vector elements.

Participants are expected to have a working knowledge of Python and basic knowledge of finite element methods. Bring your laptops and be ready to solve a set of interesting exercises. Participants are encouraged to download and install the FEniCS software on their laptops prior to the course. Participants are also encouraged to obtain a copy of the FEniCS book. The book and the software are freely available from the FEniCS Project web site: `http://fenicsproject.org/`

The course will be given by Anders Logg, Professor of Computational Mathematics at Chalmers University of Technology, Sweden. Logg is co-founder and one of the leading developers of the FEniCS Project.

FEniCS PROJECT