

Getting started with FEniCS

1. FEniCS overview

FEniCS is a powerful, open-source suite of tools for automated solution of PDEs using finite elements. Part of the power for FEniCS is the ease with which one can create FE solvers by describing PDEs using weak forms in nearly-mathematical notation. The FEniCS software, in addition to extensive documentation and examples, can be found at the FEniCS Project website, <http://fenicsproject.org/>.

FEniCS includes a number of powerful features, which are described at <http://fenicsproject.org/about/features.html>. These include:

- Automated solution of variational problems
- Automated error control and adaptivity
- An extensive library of finite elements
- High performance linear algebra through backends to such libraries as PETSc and Trilinos.
- Visualization via a simple interactive plotting function, as well as output in VTK format
- FEniCS can be used from both Python and C++
- Extensive documentation

2. FEniCS resources

The documentation for FEniCS is extensive. Resources include:

- **FEniCS Demos.** These documented demonstration programs are a great way to learn the different features in FEniCS. They can be found at: <http://fenicsproject.org/documentation/dolfin/1.5.0/python/demo/index.html>
They come already packaged in FEniCS when you install it; the appropriate directory depends on your operating system, and the paths can be found here: <http://fenicsproject.org/documentation/demos.html#finding-demos>
- **Quick Programmer's References.** Some of the classes and functions in DOLFIN are more frequently used than others. The Python implementations are described in http://fenicsproject.org/documentation/dolfin/1.5.0/python/quick_reference.html. See also <http://fenicsproject.org/documentation/dolfin/1.5.0/python/genindex.html> for the Complete Programmer's References.
- **Getting Help.** See: <http://fenicsproject.org/support/>

Other resources, although a little outdated and not fully compatible with the latest versions of FEniCS, include

- **FEniCS Tutorial:** This is the best starting point; it describes the Python interface to FEniCS: <http://fenicsproject.org/documentation/tutorial/index.html>
The tutorial is also available as a PDF document: http://fenicsproject.org/_static/tutorial/fenics_tutorial_1.0.pdf
All of the Python codes described in the tutorial can be downloaded as a tarball from: http://fenicsproject.org/_static/tutorial/fenics_tutorial_examples.tar.gz

- **The FEniCS Book:** All 732 pages of the FEniCS book (*Automated Solution of Differential Equations by the Finite Element Method*) can be downloaded (legally!) from here: <http://launchpad.net/fenics-book/trunk/final/+download/fenics-book-2011-10-27-final.pdf>
This is the comprehensive reference to FEniCS, along with many examples of the applications of FEniCS to problems in science and engineering. You will notice that the first chapter of the book is just the FEniCS Tutorial (with some minor editorial differences).
- **The FEniCS Manual.** This is a 200-page excerpt from the FEniCS Book, including the FEniCS Tutorial, an introduction to the finite element method, and documentation of DOLFIN and UFL: <http://launchpad.net/fenics-book/trunk/final/+download/fenics-manual-2011-10-31.pdf>
Since it's an excerpt from the FEniCS Book, you probably won't need it.

3. Installing FEniCS

All of the Python codes for the examples and supporting materials for the exercises in this course require FEniCS version 1.5.0. Previous versions of FEniCS are not supported, and minor modifications are required to run the materials using FEniCS 1.6.0. The following steps will get you up and running with FEniCS on your system.

- **MacOS 10.9 and 10.10 systems:**¹

Download FEniCS 1.5.0 from http://fenicsproject.org/download/older_releases.html#older-releases. Find your MacOS version (either 10.9 or 10.10) and download the appropriate binaries of FEniCS 1.5.0. If you are running bash as default shell, you can add the following line to your `.profile` file in your home directory:

```
source /Applications/FEniCS.app/Contents/Resources/share/fenics/fenics.conf
```

Alternatively you can just double-click on the FEniCS icon in your Applications directory and that will generate a new shell preconfigured with the paths that FEniCS needs. Just run FEniCS from within this shell.

FEniCS demo programs are located under
`/Applications/FEniCS.app/Contents/Resources/share/dolfin/demo`

- **Ubuntu LTS 14.04:**²

Open a shell and run the following commands:

```
sudo add-apt-repository ppa:fenics-packages/fenics-1.5.x
sudo apt-get update
sudo apt-get install -y fenics
sudo apt-get dist-upgrade
sudo apt-get install -y ipython-notebook
sudo apt-get install -y paraview
```

¹FEniCS does not fully support MacOS 10.11 (El Capitan). If you are using MacOS 10.11, please follow the instructions below under *Any other OS*.

²The same installation instructions may also work for different version of Ubuntu or other Debian-based versions of Linux.

NOTE: to minimize conflicts with other libraries already installed on your system it is suggested to start from a fresh installation of Ubuntu.

If in the future you decide to uninstall FEniCS and remove all its dependencies, you can run the following commands:

```
sudo apt-get purge --auto-remove fenics
sudo ppa-purge ppa:fenics-packages/fenics-1.5.x
```

FEniCS demo programs are located under
/usr/share/dolphin/demo/ .

- **ICES Linux Desktop:**

Open a shell and run the following commands:

```
module purge
module load sl6 gcc/4.8 python cmake mpich2/1.4.1p1 mkl vtk petsc fenics
```

Note: you will have to run the above commands each time you open a new shell. If you would like to run FEniCS without having to type these commands each time you open a new shell, you can add the commands in your default shell profile (e.g. `.bashrc` if your default shell is `bash`).

WARNING: The ICES Linux Desktop does not support ipython notebooks at this time. We have sent a support request to Sysnet to address this issue.

FEniCS demo programs are located under
/usr/share/dolphin/demo/

You should copy this folder to your home directory if you wish to run any of the examples.

- **Any other OSES, including Windows, MacOS 10.11, and other Linux distributions:**

You can download a Linux virtual machine running Ubuntu 14.04 and FEniCS 1.5 from

<http://users.ices.utexas.edu/~uvilla/hippylib.ova>

(Warning: this file is 3.1GB!) To run the virtual machine you should use VirtualBox from here:

<https://www.virtualbox.org/wiki/Downloads>

Instructions on how to import and run the virtual machine can be found at:

https://docs.oracle.com/cd/E26217_01/E26796/html/qs-import-vm.html

The username and password for the virtual machine are both `hippylib`.

To check the FEniCS installation on your system, go to the demo folder (see above for the exact location of this folder in your system) and run `demo_poisson.py` by typing the following at the command lines:

```
cd documented/poisson/python/
python demo_poisson.py
```

After compilation, you'll get a message saying

Solving linear variational problem.

and a simple plot of the solution will pop up in a new window. If you mouse over the Help tag in the low left, you'll get a list of some keyboard commands for interactive visualization. You can quit this run by typing q or Q.

The Poisson equation code `poisson_demo.py` is described extensively in the FEniCS Tutorial (pages 5–15), as well as online at

<http://fenicsproject.org/documentation/dolfin/1.5.0/python/demo/documented/poisson/python/documentation.html>

4. Additional help

If you have questions regarding FEniCS or have problems running with the FEniCS examples provided in this class, please feel free to contact Umberto Villa (uvilla@ices.utexas.edu).