

# Pencil Code: Quick Start guide

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# 1 Download the Pencil Code

The Pencil Code is an open source code written mainly in Fortran and available under GPL. General information can be found at our official homepage:

`http://pencil-code.nordita.org/`.

The latest version of the code can be downloaded with `svn`. In the directory where you want to put the code, type:

```
svn checkout http://pencil-code.googlecode.com/svn/trunk/ pencil-code
```

The downloaded `pencil-code` directory contains several sub-directories

1. `doc`: you may build the latest manual as PDF by issuing the command `make` inside this directory
2. `samples`: contains many sample problems
3. `config`: has all the configuration files
4. `src`: the actual source code
5. `bin` and `lib`: supplemental scripts
6. `idl`, `python`, `julia`, etc.: data processing for diverse languages

# 2 Configure the shell

For a quick start, you need to load some environment variable into your shell. First, you enter to the freshly downloaded directory:

```
cd pencil-code
```

Depending on which shell you use, you can do that by a simple command:

```
. source.sh
```

that will work for `bash` and all `sh`-compatible shells, while this command:

```
source source.csh
```

is for `tcsh` and any `csh`-compatible shell.

# 3 Fortran

A Fortran and a C compiler are needed to compile the code. Both compilers should belong to the same distribution package and version (e.g. GNU GCC 4.8.3, 64 bit Linux).

### 3.1 Fortran on a Mac

For Mac, you first need to install Xcode from the AppleDeveloper site <http://developer.apple.com/>. This requires you to first register as a member. An easy to install gfortran can be found at <http://gcc.gnu.org/wiki/GFortranBinaries>. Just download it and it comes with an installer. It installs in the directory `/usr/local/gfortran` with a symbolic link in `/usr/local/bin/gfortran`. It might be necessary to add the following line in the `.cshrc`-file in the home folder:

```
setenv PATH /usr/local/bin:\$PATH
```

## 4 Try a sample

Go to a folder that contains one of the many available samples, e.g.:

```
cd samples/ld-tests/jeans-x
```

You may also start with a fresh directory and copy over the files from one of the samples.

### 4.1 Setting up...

One command sets up all needed symbolic links to the original Pencil Code directory:

```
pc_setupsrc
```

### 4.2 Makefile

Two basic configuration files define a simulation setup: `src/Makefile.local` contains a list of modules that are being used, and `src/cparam.local` defines the grid size and the number of processors to be used. Take a quick look at these files...

#### 4.2.1 Single-processor

An example using the module for only one processor would look like:

```
MPICOMM=nompicomm
```

For most modules there is also a `no`-variant which switches that functionality off.

In `src/cparam.local` the number of processors needs to be set to 1 accordingly:

```
integer, parameter :: ncpus=1,nprocx=1,nprocy=1,nprocz=ncpus/(nprocx*nprocy)
integer, parameter :: nxgrid=128,nygrid=1,nzgrid=128
```

### 4.2.2 Multi-processor

If you like to use MPI for multi-processors simulations, be sure that you have a MPI library installed and change `src/Makefile.local` to use MPI:

```
MPICOMM=mpicomm
```

Change the `ncpus` setting in `src/cparam.local`. Think about how you want to distribute the volume on the processors — usually, you should have 128 grid points in the x-direction to take advantage of the SIMD processor unit. For compilation, you have to use a configuration file that includes the `_MPI` suffix, see below.

## 4.3 Compiling...

In order to compile the code, you can use a pre-defined configuration file corresponding to your compiler package. E.g. the default compilers are `gfortran` together with `gcc` and the code is being built with default options by issuing the command:

```
pc_build
```

### 4.3.1 Using a different compiler (optional)

If you prefer to use a different compiler package (e.g. using `ifort` or `MPI`), you may try:

```
pc_build -f Intel
pc_build -f GNU-GCC_MPI
```

More pre-defined configurations are found in the directory `pencil-code/config/compilers/*.conf`.

### 4.3.2 Changing compiler options (optional)

Of course you can also create a configuration file in any subdirectory of `pencil-code/config/hosts/`. By default, `pc_build` looks for a config file that is based on your `host-ID`, which you may see with the command:

```
pc_build -i
```

You may add your modified configuration with the filename `host-ID.conf`, where you can change compiler options according to the Pencil Code manual. A good host configuration example, that you may clone and adapt according to your needs, is `pencil-code/config/hosts/IWF/host-andromeda-GNU_Linux-Linux.conf`.

## 4.4 Running...

The initial conditions are set in `start.in` and the parameters for the main simulation run can be found in `run.in`. In `print.in` you can choose which physical quantities are written to the file `data/time_series.dat`.

Be sure you have created an empty `data` directory. It is now time to run the code:

```
mkdir data
pc_run
```

Welcome to the world of Pencil Code!

## 4.5 Troubleshooting...

If compiling fails, please try first (yes, `cleann` is correct):

```
make cleann
pc_setupsrc
pc_build
```

If one of the above steps fails, you may report to our mailing list: <http://pencil-code.nordita.org/contact.php>. In your report, please state the exact point in this quick start guide that fails for you (including the full error message) — and be sure you precisely followed all non-optional instructions from the beginning.

In addition to that, please report your operating system (if not Linux-based) and the shell you use (if not `bash`). Also please give the full output of these commands:

```
bash
cd path/to/your/pencil-code/
source sourceme.sh
echo $PENCIL_HOME
ls -la $PENCIL_HOME/bin
cd samples/ld-tests/jeans-x/
gcc --version
gfortran --version
make cleann
pc_setupsrc
pc_build -d
```

If you plan to use MPI, please also provide the full output of:

```
mpicc --version
mpif90 --version
mpiexec --version
```

## 5 Data post-processing

### 5.1 IDL visualization (optional, recommended)

#### 5.1.1 GUI-based visualization (recommended for quick inspection)

The most simple approach to visualize a cartesian grid setup is to run the Pencil Code GUI and to select the files and physical quantities you want to see:

```
IDL> .r pc_gui
```

If you miss some physical quantities, you might want to extend the two IDL routines `pc_get_quantity` and `pc_check_quantities`. Anything implemented there will be available in the GUI, too.

### 5.1.2 Command-line based processing of "big data"

Please check the documentation inside these files:

pencil-code/idl/read/pc_read_var_raw.pro	efficient reading of raw data
pencil-code/idl/read/pc_read_subvol_raw.pro	reading of sub-volumes
pencil-code/idl/read/pc_read_slice_raw.pro	reading of any 2D slice from 3D snapshots
pencil-code/idl/pc_get_quantity.pro	compute physical quantities out of raw data
pencil-code/idl/pc_check_quantities.pro	dependency checking of physical quantities

in order to read data efficiently and compute quantities in physical units.

### 5.1.3 Command-line based data analysis (may be inefficient)

Several idl-procedures have been written (see in pencil-code/idl ) to facilitate inspecting the data that can be found in raw format in jeans-x/data directory. For example, let us inspect the time series data

```
IDL> pc_read_ts, obj=ts
```

The structure `ts` contains several variables that can be inspected by

```
IDL> help, ts, /structure
** Structure <911fa8>, 4 tags, length=320, data length=320, refs=1:
  IT          LONG      Array[20]
  T           FLOAT     Array[20]
  UMAX        FLOAT     Array[20]
  RHOMAX      FLOAT     Array[20]
```

The diagnostic `UMAX`, the maximal velocity, is available since it was set in `jeans-x/print.in`. Please check manual for more information.

We can now plot the evolution of the maximal velocity after the initial perturbation we inserted in `start.in`:

```
IDL> plot, ts.t, alog(ts.umax)
```

The complete state of the simulation is saved as snapshots in `jeans-x/data/proc0/VAR*` every `dsnap` time units, as defined in `jeans-x/run.in`. These states are loaded with, for example:

```
IDL> pc_read_var, obj=ff, ivar=1, /trimall
```

Similarly `tag_names` will provide us with the available variables:

```
IDL> print, tag_names(ff)
T X Y Z DX DY DZ UU LNRHO POTSELF
```

The logarithm of the density can be inspected by using a GUI:

```
IDL> cslice, ff.lnrho
```

Of course, for scripting one might use any quantity from the `ff` structure, like calculating the average density:

```
IDL> print, mean(exp(ff.lnrho))
```

## 5.2 Python visualization (optional)

Be advised that the Python support is still not complete or as feature-rich as for IDL.

### 5.2.1 Python module requirements

For this example we use the modules: `numpy` and `matplotlib`.

### 5.2.2 Using the 'pencil' module

After executing the `sourceme.sh` script (see above), you should be able to import the `pencil` module:

```
import pencil as pc
```

Some useful functions:

<code>pc.read_ts</code>	read <code>time_series.dat</code> file. Parameters are added as members of the class
<code>pc.read_slices</code>	read 2D slice files and return two arrays: (nslices,vsize,hsize) and (time)
<code>pc.animate_interactive</code>	assemble a 2D animation from a 3D array