

CE 4333 Practical Computational Hydraulics using R

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1 Introduction and Getting Started

In the 1990s Civil Engineering programs reduced programming courses in a effort to recover hours for other topics – a logical decision at the time, but with some consequences. The philosophy was that engineers would not need to be able to write computer programs, but instead just use them. Microsoft Excel and Lotus 1-2-3 were the dominant spreadsheet software programs (Borland QuatroPro was a close third), and with macro instruction capability, much legitimate engineering computation could be performed within these tools. In fact I developed Excel spreadsheets that could solve multi-dimensional diffusion problems (3D groundwater flow) using fully implicit finite difference methods. These spreadsheets were slow relative to MODFLOW, but you could watch the solutions evolve – ultimately the process was deemed a waste, because of the ever present “... there is no longer a need for engineers to be able to write programs.” Later on I developed spreadsheets to perform pressurized pipe network simulation, gradually varied flow simulation, and rudimentary water-hammer and St-Venant equation solutions. The spreadsheets were never really practical (yes they worked well, produced the same results as professional products, but were always intended a pedagogical tools), but they proved an important point – if you could teach a computer to follow an algorithm it made you a more self-help user of the professional tools.

In 2014 several of my students expressed desire to understand programming – they all know how to write code, but feel they don’t know how to build algorithms (and implement them). This workbook is an attempt to remedy that student self-identified weakness. I conducted several one-to-one classes (as special topics); they learned a lot, I learned even more. This book is a tribute to their interests.

The workbook plan is to introduce a programming tool – I have selected **R** because it has a rich development environment already available, graphics is almost trivial, then apply that tool to selected hydraulics problems of practical value. In the end the reader ends up with a toolkit that can either stand-alone, or more likely supplement professional tools they will eventually use.

R is freeware, but it is built and maintained by a consortium of programmers and statisticians. They have evolved the environment to work on most of the main architectures (MacOS, Windows, Linux); there are even parallel processor and GPU builds available, and a company called RStudio provides the APIs to even run it server side. Much of the underlying code is C, C++, and well proven FORTRAN routines.

1.1 About R

R is a open source environment that runs on Windows, Linux/UNIX, and Mac OS X. The individual binaries are unique to each OS and architecture, but **R** “source” is interchangeable among machines. With very minor differences, an **R** script will run equally well on any machine.

R is a statistical analysis tool, it is also a programming tool and language, it is also a nearly “publication” quality graphics tool. Naturally all this capability comes at a cost (especially since the software is distributed for “free”) — learning to do more than simple calculations takes some time (not much), but the skill is highly perishable. You will need to keep notes, or copies of your **R** scripts for future reference. Relearning after some time away from **R** is pretty simple, so the modeler only has to pay the steep learning cost once.

The remainder of this essay shows how to obtain and install **R** on a Windows machine. Macintosh and Linux installs are accomplished in a similar fashion. For the truly insane, the entire environment can be built from source on any machine with PERL, gcc, and gfortran compilers (default in Linux, easy to obtain for other architectures).

1.2 Getting Started

The first step required (for using **R** as a programming tool) is to install **R** on your computer. The source of the binary builds is the same regardless of the underlying operating system – the Comprehensive R Archive Network (CRAN for short). The remainder of this chapter shows how to get the tool running on the three main operating systems in current practice.

1.2.1 Windows Users

The purpose of this section is to demonstrate how to get **R** running on a Windows computer. This document assumes the following:

1. You have internet connection.
2. You have sufficient user privileges to install software on your machine. (If you need someone else to install, I did my install by running the installer as a local administrator obviously you need the password)
3. You have 60MB or so of vacant disk space on the system directory.

The step-by-step guide is presented as a series of screen captures. Obviously adjust inputs to fit your machine. The version in these screen captures is quite dated — use the most recent, stable version offered on CRAN (Comprehensive R Archive Network).



Figure 1. Google “R” (alternatively google CRAN).

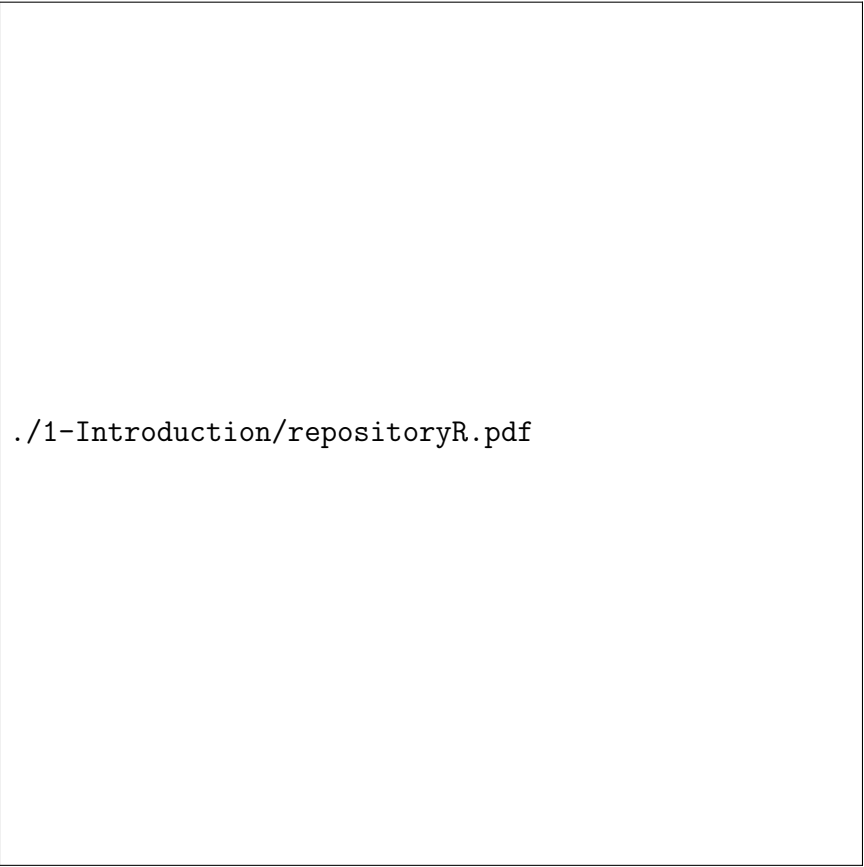
Yipee! It is running. You can install additional packages now or later. You should now have sufficient computation capability for much of the course. You may still need Python, Ruby, or Perl for data file formatting — these can wait, a lot of manipulation can be done in a text editor and using Excel.



Figure 2. Select "R" GNU project.



Figure 3. Select Download in the Left Frames (CRAN).

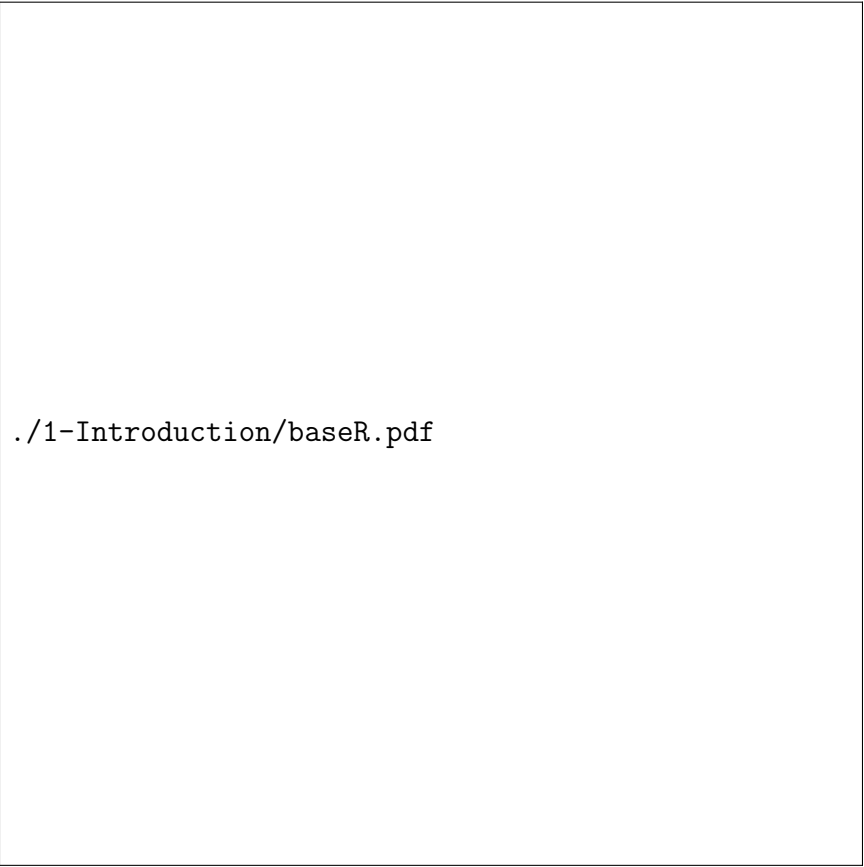


`./1-Introduction/repositoryR.pdf`

Figure 4. Choose a mirror. USA, Canada, and UK have fastest downloads.

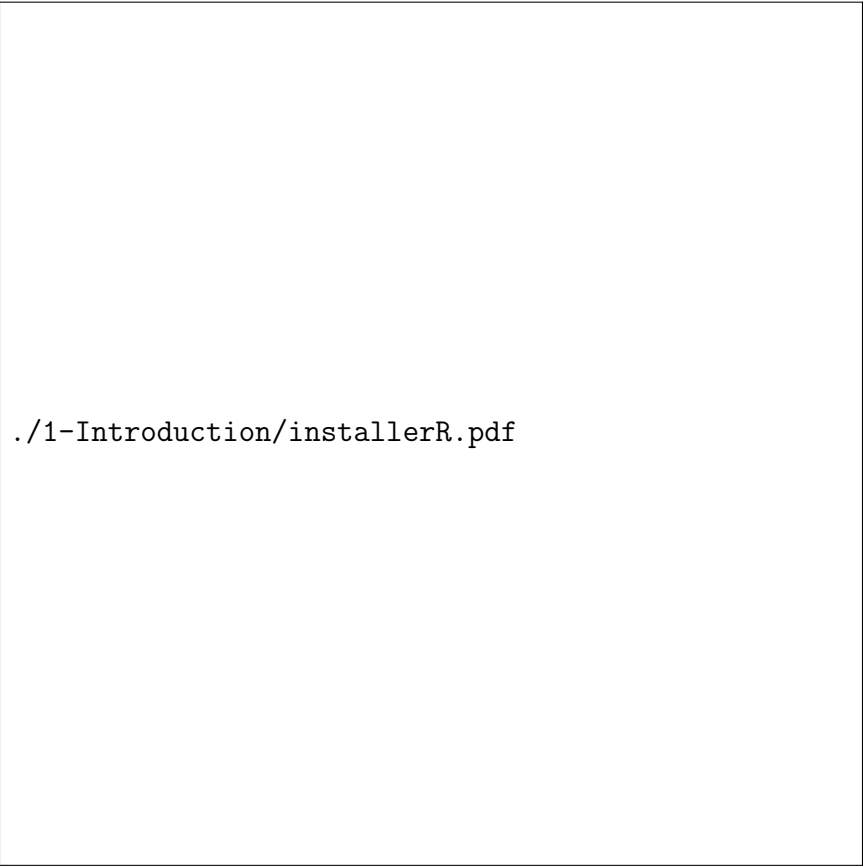


Figure 5. Select your platform : Windows, MacOSX, or Linux..



```
./1-Introduction/baseR.pdf
```

Figure 6. Select “base” to get the base packages..



`./1-Introduction/installerR.pdf`

Figure 7. Download the installer (get the documentation too — you will need it!).

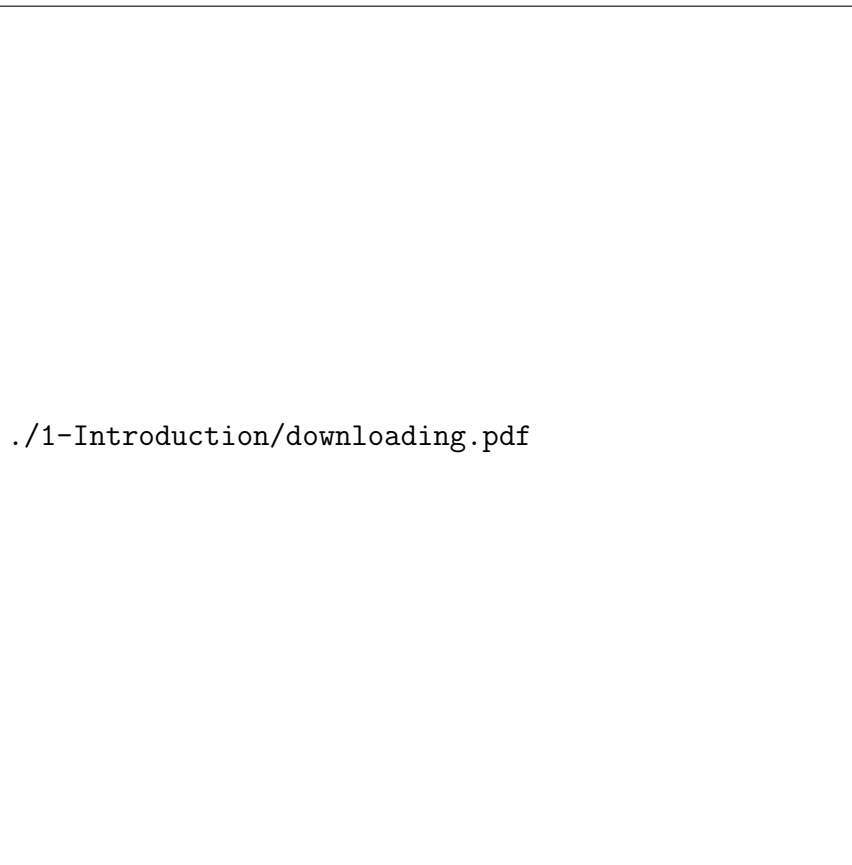

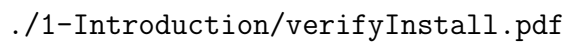


Figure 8. Downloading the system.



```
./1-Introduction/runInstall.pdf
```

Figure 9. Installer (run as administrator) running..



```
./1-Introduction/verifyInstall.pdf
```

Figure 10. Verify the install by running the program and doing something simple..

1.2.2 Macintosh OSX Users

[Replicate Windows using MacOS screen captures]

1.2.3 Linux Users

[Replicate Windows using Linux (GIMP) screen captures]

1.3 Exercises

References

Zheng, C. and Bennett, G. D. (1995). *Applied Contaminant Transport Modeling*. Van Nostrand Reinhold.