Git

An Introduction to the Version Control System

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Strathclyde Research Software Engineers

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1. Automated Version Control

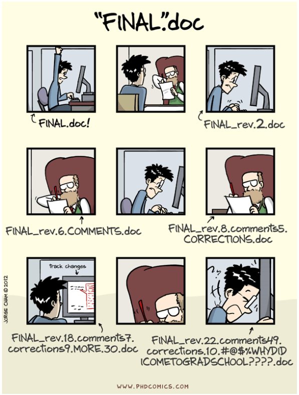
Why version control?

Problems

- Multiple, nearly identical versions of the same document
- Tracking changes is not an option for source code
- No protection against accidental deletion

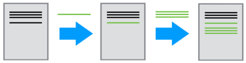
Version control systems

- **start** with a base version of the document
- **record** changes you make each step of the way
- can **revert** to any previous versions if necessary
- **never lose** a previous state of your document
- allow many people to **work in parallel**


"FINAL".doc
FINAL.doc!
FINAL_rev.2.doc
FINAL_rev.6.COMMENTS.doc
FINAL_rev.8.comments5.CORRECTIONS.doc
track changes
FINAL_rev.18.comments7.corrections9.MORE.30.doc
FINAL_rev.22.comments49.corrections.10.#@$%WHYDID ICOMETOGRADSCHOOL????.doc
JORGE CHAM © 2012
WWW.PHDCOMICS.COM

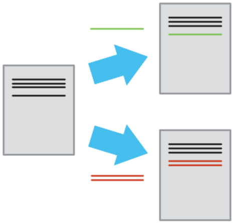
1. Automated Version Control

Sequential changes



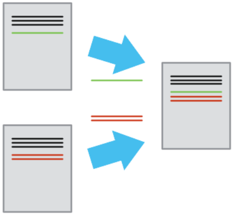
Start at the base document, apply each change, arrive at the more recent version

Diverging versions



Two users can make independent sets of changes on the same document

Merge versions



Incorporate two sets of changes into the same base document

1. Automated Version Control

Further reasons for using Git

- **Sequence of clean, logical patches**, not uncorrelated random changes
- Git as starting point for **automated unit and regression tests**, e.g. via Gitlab, GitHub
- Git for **reproducing results**, not only source code
  - configuration changes
  - data sets
  - anything in ASCII
  - LaTeXsource code
- **Collaboration** as everyone uses Git

1. Automated Version Control

Example: determine buggy version via bisection

Manually

1. Define (latest) buggy version `B`
2. Find some working version `W`
3. Check out intermediate version `I` half-way between `B` and `W`, build, run
   - working? ⇒ `W = I`
   - not working? ⇒ `B = I`
4. Goto 3

1. Automated Version Control

Another example: determine buggy version via bisection

Automated

1. Start bisect wizzard `git bisect start`
2. Define buggy version `git bisect bad someCommitID`
3. Define working version `git bisect good anotherCommitID`
4. Git checks out intermediate version, build, run
   - working? ⇒ `git bisect good`
   - not working? ⇒ `git bisect bad`
5. Git goes to 4

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2. Basic Tasks

In this section

- Setting Up Git
- Creating A Git Repository
- Tracking Changes
- Exploring History

2.1. Setting Up Git

Git comes in many different forms. We use **Git on the command line**.

- It's the only place you can run **all** Git commands.
- If you know the command line version, you can figure out how to run the GUI version.
- Everyone has the same command line tools.

On Linux

`$ sudo dnf install git-all` (Fedora)
`$ sudo apt install git-all` (Debian)

On Mac

`$ brew install git` (Homebrew)
`$ port install git` (Macports)
part of XCode IDE

On Windows

Git for Windows: `https://git-scm.com/download/win`
GitHub Desktop: `https://desktop.github.com`
Git Chocolatey: `https://chocolatey.org/packages/git`

2.1. Setting Up Git

When we use Git on a new computer for the first time, we need to configure a few things.

Here are a few examples of configurations we will set as we get started with Git:

- your name and email address
- and that we want to use these settings globally (i.e. for every project)

On a command line, Git commands are written as **`git verb options`**, where **`verb`** is what we actually want to do and **`options`** is additional optional information which may be needed for the verb.

So here is how Dracula sets up his new laptop:

```
$ git config --global user.name "Vlad Dracula"
$ git config --global user.email
    "vlad@tran.sylvan.ia"
```

2.1. Setting Up Git

Quite helpful and important are the commands to look up the manual

For a general overview of a range of Git commands

```
$ git --help
```

For a overview of specific Git command (here command = `verb`)

```
$ git verb -h
```

For an in-depth manual of specific Git command

```
$ git verb --help
```

For more information please check the **Git online documentation** at
https://git-scm.com/docs

2.2. Creating A Git Repository

Create a directory in your current working directory

```
$ mkdir git_exercise
```

Change to the new directory

```
$ cd git_exercise
```

Create the Git repository

```
$ git init
```

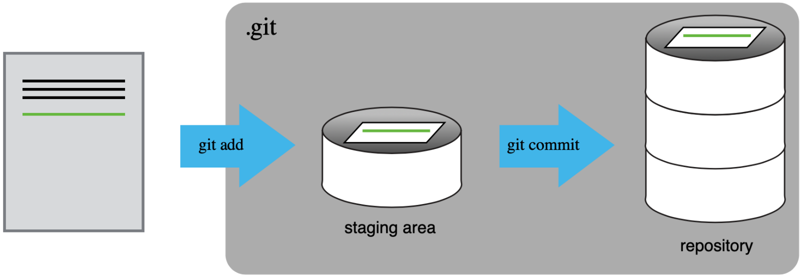
Note

An invisible file `.git` is created that stores all the history and dependencies of the repository.

2.3. Tracking Changes

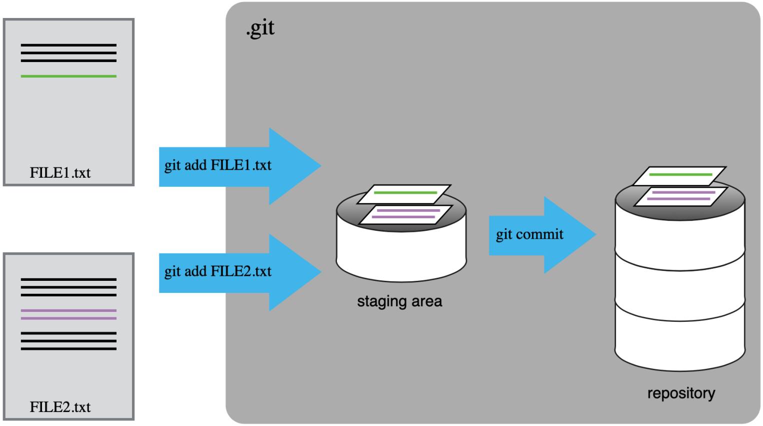
Think of Git as taking snapshots of your project in a two-step process:

- `git add` specifies **what** will go into a snapshot
- `git commit` **takes the actual snapshot** and records it permanently



2.3. Tracking Changes

It is of course possible to add multiple files (or changes thereof) before committing these, i.e. taking the snapshot.



2.3. Tracking Changes

Check the status

```
$ git status
```

Output if working directory / repository is brand new

```
On branch master
No commits yet
nothing to commit (create/copy files and use "git
    add" to track)
```

Now create a new file `hello_world.py` in your working directory that prints 'Hello World!'

2.3. Tracking Changes

When you check the status again, you will now see there is an untracked file.

```
$ git status
```

Output if working directory differs, but new file is not yet being tracked

```
On branch master
No commits yet
Untracked files:
  (use "git add <file>..." to include in what will
      be committed)
       hello_world.py

nothing added to commit but untracked files present
    (use "git add" to track)
```

2.3. Tracking Changes

Add your new file and start the tracking.

```
$ git add hello_world.py
```

Check the status again

```
$ git status
```

Output if working directory differs and file is being tracked

```
On branch master
No commits yet
Changes to be committed:
  (use "git rm --cached <file>..." to unstage)
      new file: hello_world.py
```

2.3. Tracking Changes

Now commit the change and record it permanently.

```
$ git commit -m 'Added new file'
```

Output of `git commit`

```
[master (root-commit) b3557d4] Added new file
 1 file changed, 8 insertions(+)
 create mode 100644 hello_world.py
```

2.3. Tracking Changes

Check the status with **git status** and you get the following message:

```
On branch master
nothing to commit, working tree clean
```

You can check the log to see your commits. The most recent appears first.

```
$ git log
```

```
commit 249156049502e47d839735c34e31830885bc5092
    (HEAD -> master)
Author: Oliver Henrich
    <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:56:07 2020 +0100
   Added new file
```

2.4. Exploring History

When working with repos, you often want to **review changes before committing them** or **revert to a previous version** of the file.

Add an additional line to the previous `hello_world.py` file. Check the **differences between your local and remote repository** with

```
$ git diff
```

Additional line `'print('Hello Scotland!')'` in local file (+)

```
diff --git a/hello_world.py b/hello_world.py
index 73fb7c3..e6f9107 100644
--- a/hello_world.py
+++ b/hello_world.py
@@ -1 +1,2 @@
 print('Hello World!')
+print('Hello Scotland!')
```

2.4. Exploring History

Commit the change

```
$ git add hello_world.py
$ git commit -m 'Added additional line'
```

and check the differences again.

```
$ git diff
```

There are no differences anymore as you committed your change.

Now check the status again.

```
$ git status
```

Output of `git status`

```
On branch master
nothing to commit, working tree clean
```

2.4. Exploring History

Add another line, commit the change again and check your commit log.

Output of `git log`

```
commit 908944eb711c90f5bd46297639b34d8fc70993f0
       (HEAD -> master)
Author: Oliver Henrich
       <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:59:00 2020 +0100
   Added another additional line

commit 28f46c36b5729ab26ca719cc1468b1a6e734d597
Author: Oliver Henrich
       <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:58:15 2020 +0100
   Added additional line

commit 249156049502e47d839735c34e31830885bc5092
Author: Oliver Henrich
       <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:56:07 2020 +0100
   Added new file
```

All commits have a unique ID, but Git knows a simple way to address them:

The **last commit** appears at the top and is marked with **`HEAD`**.

The **two previous commits** are not marked, but can be conveniently addressed with **`HEAD~1`** and **`HEAD~2`**.

2.4. Exploring History

If we want to see what the differences are between the current version (**HEAD**) and version two commits ago, we can issue for instance

```
$ git diff HEAD~2
```

Additional two lines marked as different in local file (+)

```
diff --git a/hello_world.py b/hello_world.py
index 73fb7c3..547a19b 100644
--- a/hello_world.py
+++ b/hello_world.py
@@ -1 +1,3 @@
 print('Hello World!')
+print('Hello Scotland!')
+print('Hello Glasgow!')
```

2.4. Exploring History

Assume you want to obtain the previous version without the additional line.

First you need to **check the log for the ID of the previous commit**.

Output of `git log`

```
commit 28f46c36b5729ab26ca719cc1468b1a6e734d597
Author: Oliver Henrich
       <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:58:15 2020 +0100
   Added additional line
```

The commit ID is the long bit starting 28f46c36b5. . .

It is **usually sufficient to specify only 7 digits**.

Use the **`git checkout`** command to retrieve a previous version.

```
$ git checkout 28f46c36b5 hello_world.py
```

Note: Do not forget the filename at the end as this will 'detach the `HEAD`'!

To **retrieve the latest version** again use

```
$ git checkout master hello_world.py
```

2.4. Exploring History

The previous command will not revert the commit (check e.g. `git log`).

To **revert an erroneous commit, first look for its ID** and use `git revert`.

Output of `git log`

```
commit 908944eb711c90f5bd46297639b34d8fc70993f0
       (HEAD -> master)
Author: Oliver Henrich
       <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:59:00 2020 +0100
   Added another additional line

commit 28f46c36b5729ab26ca719cc1468b1a6e734d597
Author: Oliver Henrich
       <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:58:15 2020 +0100
   Added additional line
```

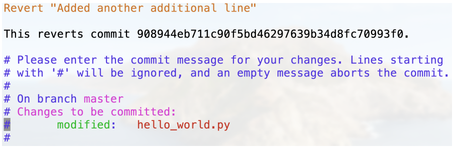
We want to revert the commit starting 908944eb71...

We want the current version to be this one.

```
$ git revert 908944eb71
```

This creates a new commit with the previous version of the file.

2.4. Exploring History



```
Revert "Added another additional line"

This reverts commit 908944eb711c90f5bd46297639b34d8fc70993f0.

# Please enter the commit message for your changes. Lines starting
# with '#' will be ignored, and an empty message aborts the commit.
#
# On branch master
# Changes to be committed:
#       modified:   hello_world.py
#
```

A dialogue window opens that asks you for a message providing a template.

```
commit 15f36c3bd31f594504756326df6b3baeb2d0982c (HEAD -> master)
Author: Oliver Henrich <ohenrich@users.noreply.github.com>
Date: Thu Sep 3 17:29:03 2020 +0100
   Revert "Added another additional line"
   This reverts commit 908944eb711c90f5bd46297639b34d8fc70993f0.

commit 908944eb711c90f5bd46297639b34d8fc70993f0
Author: Oliver Henrich <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:59:00 2020 +0100
   Added another additional line

commit 28f46c36b5729ab26ca719cc1468b1a6e734d597
Author: Oliver Henrich <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:58:15 2020 +0100
   Added additional line

commit 249156049502e47d839735c34e31830885bc5092
Author: Oliver Henrich <ohenrich@users.noreply.github.com>
Date: Wed Sep 2 16:56:07 2020 +0100
   Added new file
```

Your commit log has now an extra entry.

3. Collaborative Software Development

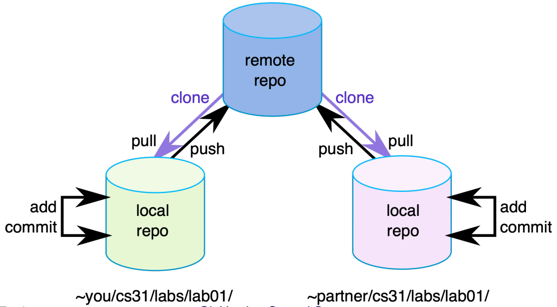
In this section

- Creating Remote Repositories on GitHub
- Collaborating On GitHub
- Conflicts

3.1. Creating Remote Repositories on GitHub

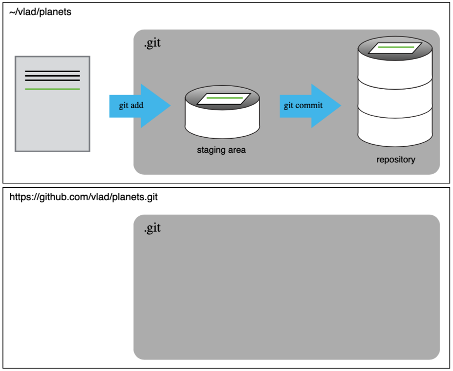
One of the main reasons for using repositories is also to **collaborate with other people** and **work on the same code**. This is done through a **remote repository**.

***Pulling* retrieves from** the remote repo.
***Pushing* deposits into** the remote repo.
***Cloning* checks out a private copy** of the remote repo.



3.1. Creating Remote Repositories on GitHub

Your current situation looks like this



We will now **export your existing local** repo to the **newly created remote** repo on GitHub.

3.1. Creating Remote Repositories on GitHub

The full documentation is available on `https://docs.github.com/en`, under **GitHub.com** → **Importing your projects** → **Adding an existing project to GitHub using the command line**.

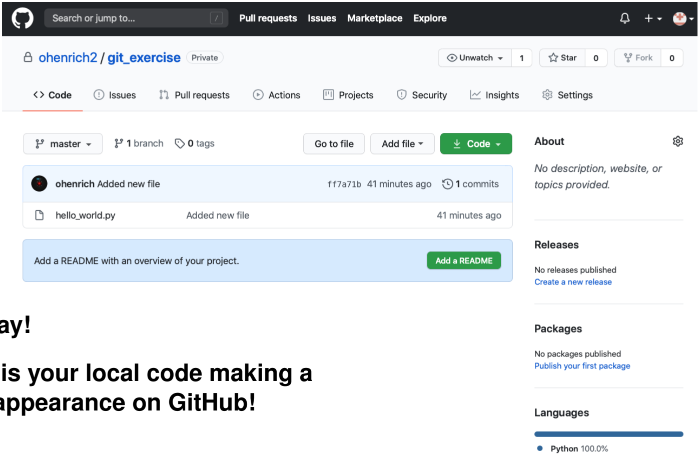
On GitHub, look up the URL of your remote repo.

On the command line change to the directory of your local repo and issue the following sequence of commands replacing username, etc accordingly.

```
$ cd git_exercise
$ git remote add origin
    https://github.com/username/repo_name.git
$ git branch -M master
$ git push -u origin master
```

3.1. Creating Remote Repositories on GitHub

On GitHub check what's in your remote repository.



Search or jump to...

Pull requests Issues Marketplace Explore

ohenrich2 / git_exercise Private

Unwatch 1 Star 0 Fork 0

Code Issues Pull requests Actions Projects Security Insights Settings

master 1 branch 0 tags Go to file Add file Code

ohenrich Added new file ff7a71b 41 minutes ago 1 commits

hello_world.py Added new file 41 minutes ago

Add a README with an overview of your project. Add a README

About

No description, website, or topics provided.

Releases

No releases published
Create a new release

Packages

No packages published
Publish your first package

Languages

Python 100.0%

Hooray!

Here is your local code making a first appearance on GitHub!

3.2. Collaborating On GitHub

In Section 2.6 we **exported** an existing ***local*** **repository** to your GitHub profile to **create a remote repository**.

The inverse process of **importing** an existing ***remote*** **repository** from GitHub is called **cloning**.

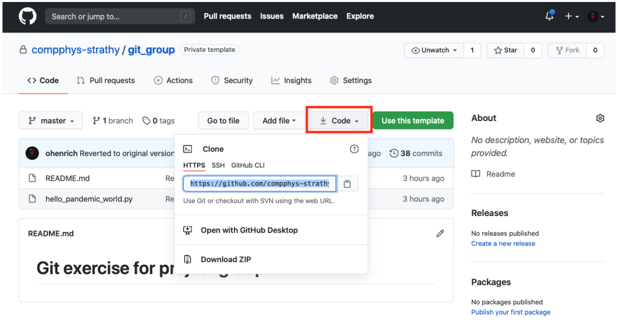
Cloning produces a **local copy of the remote repository** on your machine. It requires

- the **URL of the remote repository**
- the **`git clone`** command

You can modify the local copy and **push the changes to the remote repository** on GitHub to share them with your collaborators.

3.2. Collaborating On GitHub

First navigate to the repository that you want to clone and click on the ”Code” button



ohenrich Reverted to original version ... ago 38 commits

README.md Re... 3 hours ago

hello_pandemic_world.py Re... 3 hours ago

https://github.com/compphys-strathy

Use Git or checkout with SVN using the web URL.

README.md

Git exercise for pr...

No description, website, or topics provided.

No releases published
Create a new release

No packages published
Publish your first package

Copy the URL, e.g. by pressing the button next to it.

3.2. Collaborating On GitHub

On your command line in your working directory issue the following command replacing **URL** with the actual URL:

```
$ git clone URL
```

Output of `git clone URL`

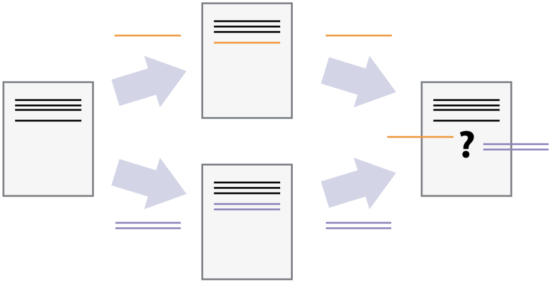
```
Cloning into 'git_group'...
remote: Enumerating objects: 109, done.
remote: Counting objects: 100% (109/109), done.
remote: Compressing objects: 100% (79/79), done.
remote: Total 109 (delta 33), reused 96 (delta 27), pack-reused 0
Receiving objects: 100% (109/109), 14.32 KiB | 4.77 MiB/s, done.
Resolving deltas: 100% (33/33), done.
```

You can clone the repository it into a different name than the default name (the name on GitHub), e.g. **blablabla** by adding this after the URL.

```
$ git clone URL blablabla
```

3.3. Conflicts

Conflicts emerge when **several** people work on the **same** code and **update the remote repo**.



The orange line and the purple line are approximately at the same position in the file.

3.3. Conflicts

Let's look at our `Hello World!` example.

Your collaborator has checked in the following version:

```python
print('Hello World!')
print('Hello Scotland!')
print('Hello City of
    Glasgow!')
```

Your version differs in the last line:

```python
print('Hello World!')
print('Hello Scotland!')
print('Hello Greater
    Glasgow!')
```

Output of `git push origin master`

```
To https://github.com/compphys-strathy/git_exercise.git
 ! [rejected]    master -> master (fetch first)
error: failed to push some refs to 'https://github.com/compphys-strathy/git_exercise.git'
hint: Updates were rejected because the remote contains work that you do
hint: not have locally. This is usually caused by another repository pushing
hint: to the same ref. You may want to first integrate the remote changes
hint: (e.g., 'git pull ...') before pushing again.
hint: See the 'Note about fast-forwards' in 'git push --help' for details.
```

3.3. Conflicts

What we have to do is **pull the changes from the remote repo** on GitHub into your local repo.

Git **tries to merge them automatically** into your local copy, and **if successful this can be pushed** to the remote repo on GitHub.

```
$ git pull origin master
```

Output of `git pull origin master`

```
remote: Enumerating objects: 5, done.
remote: Counting objects: 100% (5/5), done.
remote: Compressing objects: 100% (2/2), done.
remote: Total 3 (delta 0), reused 0 (delta 0), pack-reused 0
Unpacking objects: 100% (3/3), 682 bytes | 682.00 KiB/s, done.
From https://github.com/compphys-strathy/git_exercise
 * branch          master     -> FETCH_HEAD
   dbd3016..5b9c121  master -> origin/master
Auto-merging hello_world.py
CONFLICT (content): Merge conflict in hello_world.py
Automatic merge failed; fix conflicts and then commit the result.
```

3.3. Conflicts

Check what Git has done to your local file.

```
print('Hello World!')
print('Hello Scotland!')
<<<<<<< HEAD
print('Hello Greater Glasgow!')
=======
print('Hello City of Glasgow!')
>>>>>>> 5b9c121bac
```

Our change is preceded by **`<<<<<<< HEAD`**.

Git inserted **=======** as separator between the conflicting changes.

The end of the content downloaded from GitHub is marked with **>>>>>>>**.

We need to **remove** these markers, **reconcile** the changes and **check in a new version**.

3.3. Conflicts

```python
print('Hello World!')
print('Hello Scotland!')
print('Hello Greater Glasgow!')
print('Hello City of Glasgow!')
```

We remove the markers and keep both lines.

Lets' first check the status.

Output of `git status` after editing

```
git status
On branch master
Your branch and 'origin/master' have diverged,
and have 2 and 1 different commits each, respectively.
  (use "git pull" to merge the remote branch into yours)

You have unmerged paths.
  (fix conflicts and run "git commit")
  (use "git merge --abort" to abort the merge)

Unmerged paths:
  (use "git add <file>..." to mark resolution)
      both modified: hello_world.py
```

We are using the last option.

3.3. Conflicts

```
$ git add hello_world.py
$ git commit -m 'Resolved conflict'
```

Output of `git commit`

```
[master c7c8fb8] Resolved conflict
```

```
$ git push origin master
```

Minimise the number of conflicts by using this workflow:

1. Update local `git pull origin master`
2. Make changes
3. Stage changes `git add your_edited_file.py`
4. Commit changes `git commit -m "Your commit message"`
5. Update remote `git push origin master`

4. Further Information

- Excellent **Git tutorial materials** are available on the Software Carpentry website:
  `http://swcarpentry.github.io/git-novice`

software carpentry Teaching basic lab skills for research computing

- **Git Tutorial** by Robert Atkey (CIS):
  `https://gitlab.cis.strath.ac.uk/jjb15109/git-tutorial`
- ***OhMy Git!* Game** – learning the playful way: **`https://ohmygit.org`**
- Join us at our **monthly Hacky Hour every first Wednesday 2-3PM**:

  Zoom meeting room: 957-329-701
  Password: HackyHour
- Subscribe to **rse-announce mailing list** for regular information:
  `http://lists.strath.ac.uk/mailman/listinfo/rse-announce`