# JAVA / GIT

## EXERCISES

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## JAVA / GIT

### 1. FIRST JAVA PROJECT

Let's start by creating a project in **IntelliJ IDEA**:

- Open **IntelliJ** and choose the **"Create New Project"** option.
- Choose **"Java"** for the type of project and a suitable project SDK (>= 11.0.0). Click **"Next"**.
- Do not choose any of the available project templates. Click **"Next"**.
- Name the project **"helloworld"** and choose a suitable project location. Click **"Finish"**.

The steps above will create a **".idea"** directory and a **"helloworld.iml"** file. These are where **IntelliJ** keeps all the settings for your project. Notice that there is also a **"src"** directory where all the source code is stored.

On the **Project tool window** (the frame on the left), open the **"helloworld"** folder, **right-click** the **"src"** directory, and choose **"New > Java Class"**. Name your class **"Application"**, and include a **"main"** method, so that the code will look like the sample below.

```
public class Application {
    public static void main(String args[]) {
        System.out.println("Hello World");
    }
}
```

> **Tip:** an easier way to create the **main** method is to just write **'psvm'** (short for **p**ublic **s**tatic **v**oid **m**ain) and select the first auto-complete suggestion. **Try it.**
>
> You can also write **'sout'** as a shortcut for **System.out.println()**.

Right-click the **"Application"** class on the **Project tool window** and choose **"Run 'Application.main()'"**. This will compile and run your application. You should see **"Hello World"** displayed on the console.

**Congratulations, you have created your first Java application!**

Take a moment to check the **"out"** directory. This is where **IntelliJ** generates the result of the compilation process. You should be able to find there an **Application.class** file. This file contains the **bytecode**, generated from the source code, that can be run using any Java Virtual Machine (JVM).

## 2. INITIALIZE GIT REPOSITORY

**Git** is the version control system that we will use to manage the different versions of our files. It can be used **locally** (on our machine only) or with a **server** (to share code and collaborate with other team members). We will start by using it **locally**.

> **Tip:** For now, the command line will be used for all our interactions with **Git**. The use of a *nix OS is advised, but otherwise you may find the command line as **Git Bash** on Windows and **Terminal** on MacOS.

Start by changing directory to the **root directory** of our newly created **IntelliJ** project and initialize a new **Git** repository.

```
cd directory/of/my/project/helloworld # change to the directory
git init                              # initialize the git repository
```

This will create a **".git"** directory, where the **version history** of our project will be **locally** kept. You can check the current directory contents by doing:

```
ls -la       # list directory contents
```

Now let's see the **status** of your files by running the command below. Try it with and without the **-s** flag, which gives us a more concise output.

```
git status
git status -s
```

As you can see by the output, all files are reported as **untracked** by Git. You will create the first **Git** version of the project using some of these files, but it would be best to simply ignore some of the others:

- We will ignore the **"out"** directory because it can be regenerated from the source code.
- We will ignore the **".idea"** directory and **"*.iml"** files as they are **IntelliJ** specific and other developers might use different IDEs.

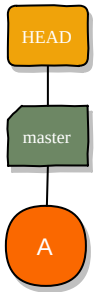
To do this, execute the command below. Notice that, after this, **git status** no longer reports the ignored files as **untracked**.

```
echo "out/" >> .gitignore     # this appends out to the .gitignore file
echo ".idea/" >> .gitignore   # this appends .idea to the .gitignore
file
echo "*.iml" >> .gitignore    # this appends *.iml* to the .gitignore
file
git status
```

> You could also just **create** and edit the **.gitignore** file using a **text/code editor**. We are just being fancy...

Now it is time to create the **first version** of our project. Let's start by adding the files to the **staging area** and then **committing** them using the commands below. Execute the **git status** command before and after each one of these steps to see how the files change state.

```
git status
git add .gitignore src              # add files to the staging area
git status
git commit -m "Initial commit"      # commit the new version
git status
```



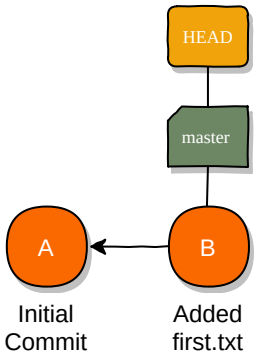
Initial Commit

If you commit without using the **-m "<message>"** flag, **git** will open your configured text/code editor so that you can input your commit message. You need to **close** the editor for the commit to **continue**.

## 3. MAKING ANOTHER COMMIT

Now that we know how to **add files** to the **staging area** and **committing them**, follow the steps below:

- Create a file called **"first.txt"** with some text – if you do this in **IntelliJ**, it will ask if you want to add it to Git. **Say no (cancel)!** We will do it manually for now.
- Add **"first.txt"** to the **staging area**.
- **Commit** with the message **"Added first.txt"**.
- Confirm that all changes are committed using **"git status"**.




## 4. INSPECTING THE LOG

To see the **list of commits** that we have so far (only two at this point) execute the command below (press **"q"** to exit).

```
git log
```

You can also provide the **–oneline** flag to the git log command to get a cleaner list of commits and the **-<number>** flag to limit the number of entries to be shown.

```
git log --oneline -1
```

The **-p** flag shows the **difference** (the **patch** output) introduced in each commit.

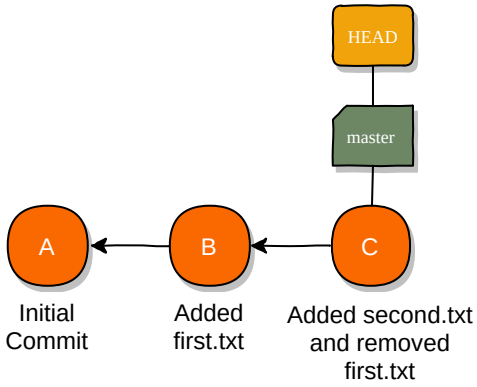
```
git log -1 -p
```

## 5. ADDING AND REMOVING

A single commit may change multiple files in different ways:

- Create a file called **"second.txt"** with some text.
- Delete the **"first.txt"** file.
- Add **"first.txt"** and **"second.txt"** to the **staging area**.
- Confirm that all changes are staged using **"git status"**.
- Commit with the message **"Added second.txt and removed first.txt"**.

- Confirm that all changes are committed using **"git status"**.
- Check out your current commits using **"git log"**.

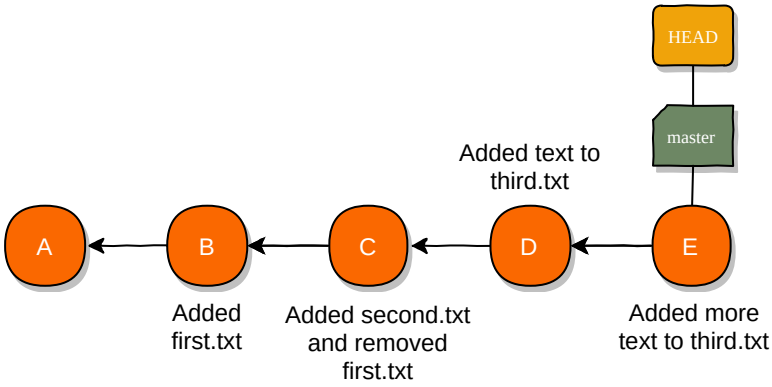



**Tip:** Deleting **"first.txt"** and adding that change to the **staging area** could have been done with a **single command**: **"git rm first.txt"**.

## 6. PARTIALLY STAGED FILES AND DIFF

- Add some text to a new file called **"third.txt"** file.
- Confirm the existing changes using **"git status"**.
- Add these changes to the **staging area**.
- Add some more text to the **"third.txt"** file.
- Confirm the existing changes using **"git status"**, noticing how the **"third.txt"** file is reported: at the same time, **staged** (for some of the changes) and **not staged** (for the rest of the changes).
- Commit with the message **"Added text to third.txt"**.
- Confirm that there are still **unstaged** changes using **"git status"**.
- Use **"git diff third.txt"** to check what these changes are.
- **Add** the remaining changes to the **staging** area.
- Commit with the message **"Added more text to third.txt"**.

- Confirm that there are no more changes using **"git status"**.
- Check out your commits using **"git log"**.




## 7. BRANCHING AND MERGING

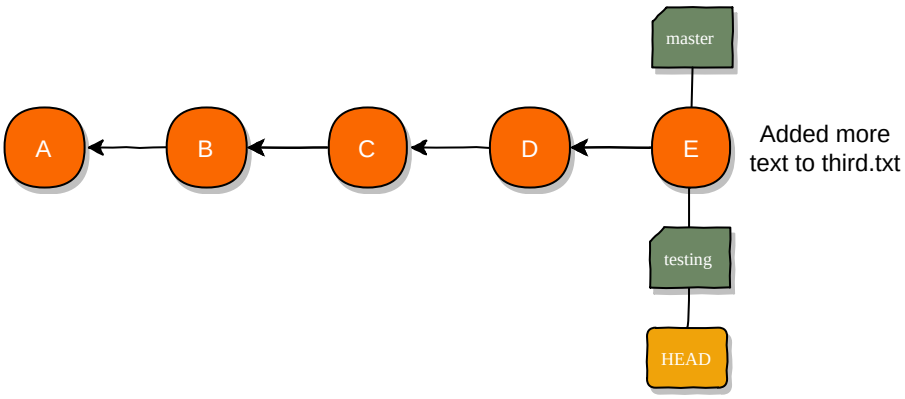
A **branch** in **Git** is a **pointer** to a particular commit. As we start making commits, we are given a default **"master"** branch. Every time we create a new commit, the **current** branch pointer **moves forward automatically**.

```
git log --oneline      # shows commits pointed by existing branches
git branch             # shows branch that we're currently working on
```

When executing the commands above we may also notice a reference to **"HEAD"**. This is a special pointer used by Git that defines which is the current branch. The **asterisk** in the output of the second command also represents the HEAD.

Let's now create a new branch with the name **"testing"** and switch to it.

```
git branch testing    # create the new branch
git branch            # check that we're still on the master branch
git checkout testing  # switch to the testing branch
git branch            # check that we're really on the testing branch
now
```



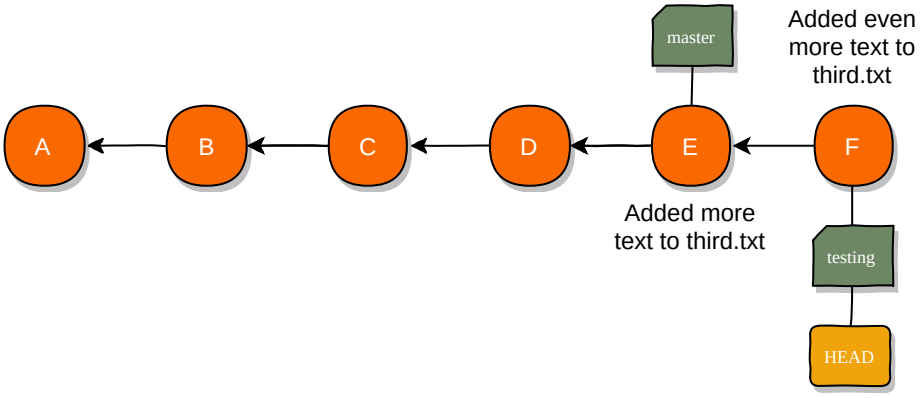

> **Tip:** The commands **"git branch testing"** and **"git checkout testing"** could be done in a single step with the equivalent command: **"git checkout -b testing"**.

Now, let's make a few changes to the **"third.txt"** file and **add a new commit** to the **"testing"** branch:

- Add some more text to the **"third.txt"** file.
- Add the changes to the **staging area**.
- Commit with the message **"Added even more text to third.txt"**.

Let's look at the effect that this has on our commit log. Run the command below:

```
git log --oneline
```

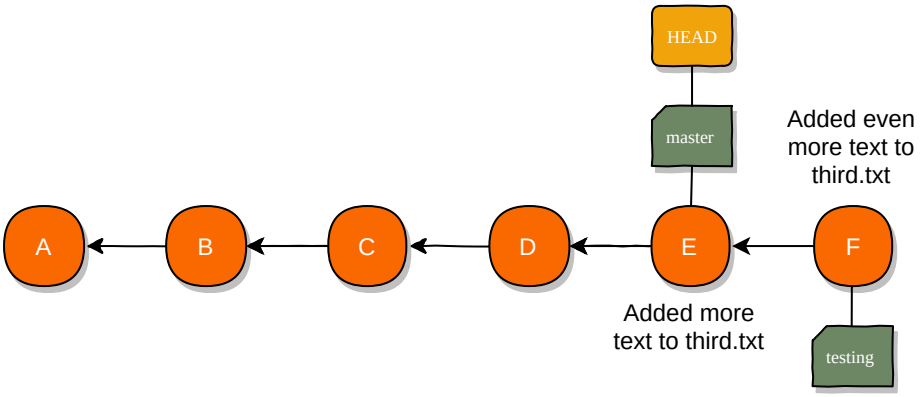



Notice that the **"testing"** branch points to the **latest commit**, but the **"master"** branch is still pointing to the **previous one**, where the branch was created. When you add a new

commit, the **current branch** — the one the **HEAD** points to — **updates** so it points to the **new commit**.

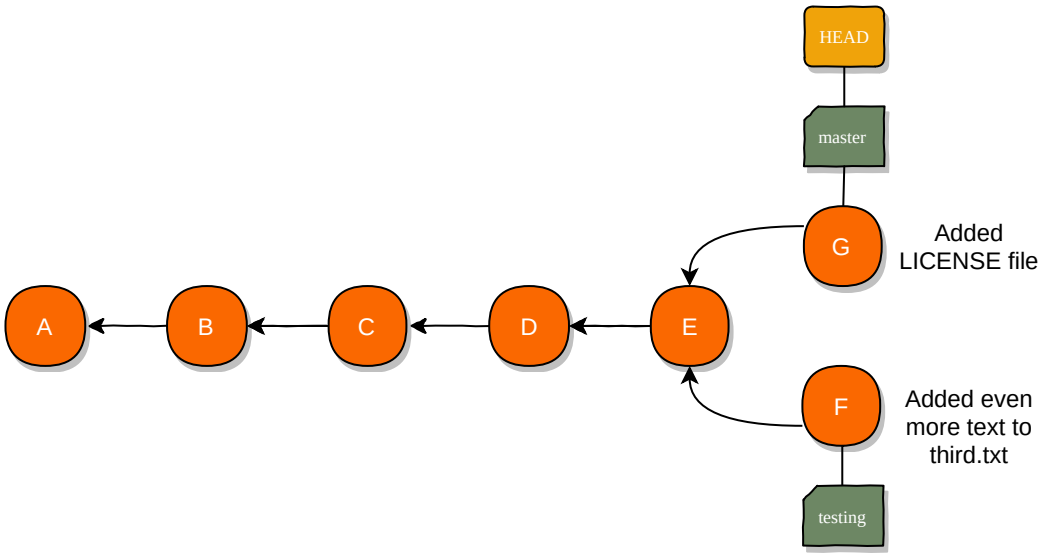
Let's switch back to the **"master"** branch and see the difference. Run the commands below, and notice how there's no trace of the commit that we made in the **"testing"** branch.

```
git checkout master                # switch back to the master branch
git log --oneline
```




Now that we are back in our **"master"** branch, let's do some more changes:

- Create a new file called **"LICENSE"** with the following text: **"This is the license text for our application"**.
- Add the changes to the **staging area**.
- Commit with the message **"Added LICENSE file"**.



At this point we have **two divergent histories** that can keep evolving independently but that will eventually be merged back together. We will now merge the **testing** branch back into the **master**.

> **Notice:** This is done **from the "master" branch**, which will **receive all the changes** from the testing branch.

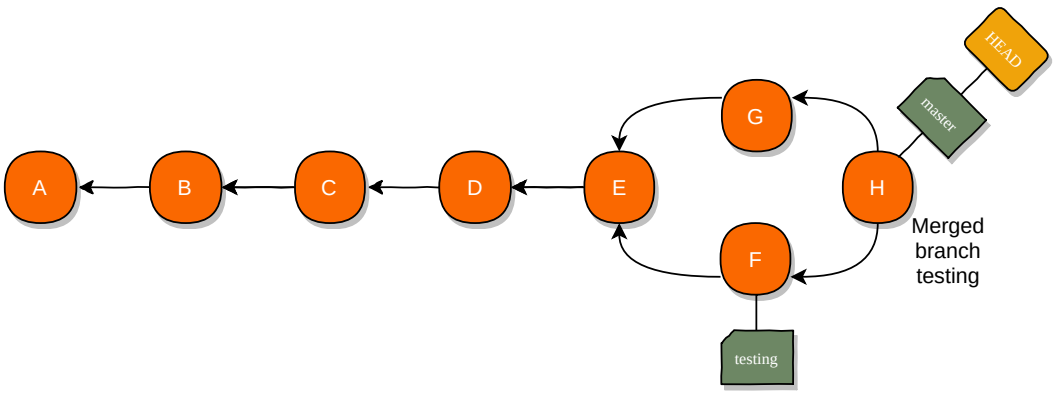
Git uses two main strategies to merge branches:

- **Fast-forward** merge (when there is no divergent work).
- **Three-way** merge (when there is divergent work).

In this example, there was divergent work, so a **three-way merge** is needed. This implies that **a new commit** with the **merged files** will be created. Execute the following command to merge the two branches and Git will ask you to enter a message for the new commit.

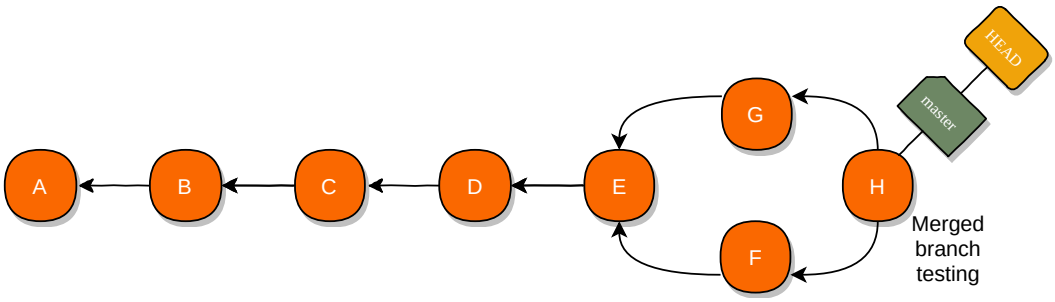
```
git merge testing
```

> **Notice:** As always, the **current branch** is the one following the new commit.




As we do not need the **"testing"** branch any longer, we can delete it. This will leave all commits intact, it will only delete the pointer.

```
git branch -d testing     # this cannot be done from inside the testing branch
```




## 8. HANDLING MERGE CONFLICTS

Not all merges work as cleanly as in the previous example. If you change the same part of the same file in the two different branches, Git won't be able to merge them cleanly. Let's try to create this scenario.

Start by creating (but not switching to) a **"testing"** branch again.

```
git branch testing
```

Now let's change our **"Application.java"** file so that it contains the following code:

```
public class Application {
    public static void main(String[] args) {
        System.out.println("Thank you for using the Hello World App");
    }
}
```

**Stage** and **commit** this change with the message **"Added a welcoming message"**.

Now change into the **"testing"** branch and notice that we still have our previous version of the **"Application.java"** file. Change it so it looks like this:

```
public class Application {
    public static void main(String[] args) {
        System.out.println("Hello World");
        System.out.println("Version 1.0");
```

```
    }
}
```

**Stage** and **commit** this change with the message **"Added the version number"**.

And finally, try to merge the changes of the **"testing"** branch back **into** the **"master"** branch.

```
git checkout master     # go back to the master branch …
git merge testing       # … and try to merge testing
```

The result of this should be the following message from Git.

```
Auto-merging src/Application.java
CONFLICT (content): Merge conflict in src/Application.java
Automatic merge failed; fix conflicts and then commit the result.
```

Note that the merge is still **in progress**, and to **complete it** we must first **resolve the conflict**. More information can be obtained by running git status, which provides the output below.

```
On branch master
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:   src/Application.java

no changes added to commit (use "git add" and/or "git commit -a")
```

So, as the output explains, our options are:

- Fix the conflicts and **manually** do the merge commit
- Abort the merge, thus **reverting** to how things were before running git merge testing.

Let's go with the first option. Open the **Application.java** file and you will find it annotated with conflict markers, like in the example below.

```
public class Application {
    public static void main(String[] args) {
<<<<<<< HEAD
        System.out.println("Thank you for using the Hello World App");
=======
        System.out.println("Hello World");
        System.out.println("Version 1.0");
>>>>>>> testing
    }
}
```

**Git** is telling us that the **first** fragment of text annotated with conflict markers came from the branch pointed to by **"HEAD"** (i.e., the master branch), and that the **second** part came from the **"testing"** branch.

We must modify this file to be like the result that we intend for the merge. Assuming that we want to keep the changes from the two divergent branches, we could simply delete the conflict markers and the line outputting **Hello World** to make the code look like the one below:

```
public class Application {
    public static void main(String[] args) {
        System.out.println("Thank you for using the Hello World App");
        System.out.println("Version 1.0");
    }
}
```

We can now **proceed** with the merge by **manually** doing the **commit**. Execute **"git status"** between each operation to see how **Git** reports the state of the merge between each operation.

```
git status
git add src/Application.java
git status
git commit -m "Merge branch 'testing'"   # commit resolved conflicts
and end the merge
```

```
git status
git log --oneline
```

As we do not need the **"testing"** branch any longer, we can delete it again:

```
git branch -d testing
```

## 9. USING REMOTES

A **remote** is a **Git repository** that is hosted **elsewhere** (another folder, the local network, the internet, ...). You can **push** and **fetch** data **to** and **from** remotes.

We already have a local repository. Let's now create an empty repository on **GitHub** where we can push our local repository to:

- Register for a **new accoun**t on GitHub (if you do not yet have one).
- Create a new repository with the name "helloworld". **Do not** add a "README", ".gitignore" or "LICENSE" files. Make the repository private (you might need a Student Developer Pack ↗)
- Add a **reference** to this new remote to your local repository by executing the command below on your project **root** directory. Do not forget to replace **"yourusername"** in the URL. As you see, we're naming this remote **"origin"**.

```
git remote add origin git@github.com:yourusername/helloworld.git
```

We can now **list** the remotes of the project by executing the command below. Try it out and check that the origin remote is setup for both **fetch** and **push**.

```
git remote -v
```

Now it is time to **push** our local repository to the remote that we have just configured. We can do this by executing the command below, but make sure that you are on the **"master"** branch locally before you do.

**Important:** In order to push to your repository, you have to authenticate with GitHub first. If we are using **SSH** (using a remote that starts with **git@github.com**), we need to setup some **SSH keys** first (see https://help.github.com/articles/connecting-to-github-with-ssh/ ↗). An easier, but not recommended, way would be to use an **HTTPS** remote https://github.com/yourusername/helloworld.git) ↗.

```
git branch
git push origin master
```

In the command above we had to explicitly say what **remote** (**"origin"**) and **remote branch** (**"master"**) we want to push to. However, it is more convenient if we do not have to type this every time. For this, we can use the notion of **tracking branches**. These are **local branches** that have a direct relationship to a specific remote branch. We can **set up** a tracking branch by running the command below, which will **connect** our **local current branch** (**"master"**) to the **master branch** on the **origin remote**.

```
git branch -u origin/master
```

And next time we can just do:

```
git push
```

When we are **collaborating** with others, often there may be changes in the remote that we **do not** yet have in our **local repository**. Let's simulate this scenario by adding a new file to the remote repository using GitHub's web interface:

- Open the github page for your repository (https://github.com/yourusername/helloworld ↗ – don't forget to replace **"yourusername"** in the URL with your GitHub username, or to refresh the page in case you already had it open).

- Press the **"Add a README"** button, and then **"Commit new file"**. This will add a **"README.md"** file to our repository.
- Now we can fetch these changes to our local repository be executing the command below.

```
git fetch
```

This only **fetches** the new commit from the **remote**, it does not merge them. The **remote branch "origin/master"** is also updated in your local repository and is now pointing to the **fetched commit**. So we can do the following to merge:

```
git merge origin/master
```

> **Tip:** We could have combined these two operations (**fetch** and **merge**) in a single command: **"git pull"**.

**Conflicts** may occur when we pull files that have also been modified and committed locally, in which case we will need to resolve them as we did with when merging a branch.

## 10. GIT CLONE AND IMPORT

What if we lose all our data and we have to recover our entire project? Let's test that:

- **Close** your project on **IntelliJ** and **remove** it from the **recent project** list.
- **Delete** your project **directory**.

Now, clone your project from the command line:

```
git clone git@github.com:yourusername/helloworld.git
cd helloworld
ls -la # checking if everything is still there
```

Now, because we did not add the **".idea"** directory to our repository, we have to **import** the project again into **IntelliJ** using the **"Import Project"** option.

## 11. COLLABORATING

- Team up with **another colleague** (both need to have computers).
- On **one of the computers**, create a new **empty repository** on **GitHub** named "Operations".
- And **invite** the **other colleague** to collaborate on that project.

> If there are **not enough computers** to do this exercise in pairs, just team up with **more students**. You will need **two computers** to perform this exercise. Or you can just **simulate** this scenario by using multiple folders in the same computer.

### NOW, ON ONE OF THE COMPUTERS:

- **Clone** the project:

```
git clone git@github.com:yourusername/operations.git
```

- And **create** a **Java project** on the **cloned folder**.
- Then create a simple Java application that **takes two numbers** from the **standard input** and **outputs** the **sum** of those two numbers.

Here is some **example** code to get you started:

```
import java.util.Scanner;

public class Application {
    public static void main(String[] args) {
        Scanner scanner = new Scanner(System.in);

        int a = scanner.nextInt();
        int b = scanner.nextInt();
```

```
            System.out.println(a + b);
        }
    }
```

- Create a **.gitignore** file with the appropriate files to ignore:

```
out/
.idea
*.iml
```

- And then **stage** and **commit** all the remaining files with the commit message "Initial commit".
- Finally, **push** the modifications back to GitHub.

### ON THE SECOND COMPUTER:

- Clone and import the project into **IntelliJ**.
- Test if the project is still working :-)

### ON THE FIRST COMPUTER:

- **Create** and **checkout** a **branch** called **"better-output"**.
- **Change** the **code** so that the **output** looks like this:

```
1
2
Result: 3
```

### ON THE SECOND COMPUTER:

- **Create** and **checkout** a **branch** called **"multiple-ops"**.
- Before reading the two *integers*, read a *String*:

```
String operation = scanner.nextLine();
```

- Then, depending on the value of that *String* execute a different operation.
- For example, if it's "sum", then sum the numbers; but if it's "mul", multiply them.

> Warning: To compare **Strings** in Java you must use:

```
if (operation.equals("sum")) ...
```

NOW, IN BOTH COMPUTERS:

- **Commit** the changes with an **appropriate** commit message.
- **Checkout** the **master** repository, and **merge** the **other** branch.
- Try **pushing** the changes back to the repository.

**One** of the pushes is going to **fail** as you now have a **divergent history** and only **fast-forward** pushes are allowed.

> You cannot push if your branches have diverged. You can **only push** changes to the server when your branch is **ahead** of the **remote branch** and a simple **fast-forward** merge can be performed.

On that computer, **first pull** the **other commit** from the repository and try **fixing** any **merge conflicts** before commiting and trying to **push again**.

Finally, on both computers pull the code from the repository and **test it**...

## 12. REVERTING CHANGES

**a)** Try changing a single file and reverting changes using either:

```
git checkout -- <filename>
```

Or:

```
git reset --hard # reverts changes on all files
```

Using **git reset –hard** resets the index (the staging area) and the working tree.

**b)** Try changing a file, staging it using **git add**, and then reverting the staging:

```
git reset HEAD <filename>
```

Or:

```
git reset # unstages all staged files
```

Using **git reset** or **git reset –mixed** resets the index (the staging area) but not the working tree. This only unstages the file. It does not revert the changes.

**c)** Try changing a file, staging it using **git add**, commiting it using **git commit**, and then reverting changes using:

```
git reset --hard <commit-id>
```

To find the **commit-id** you can use **git log** or **git log –oneline**, or you can just use **HEAD^** or **HEAD~1**.

Using **git reset –hard <commit-id>** you are effectively moving the HEAD to a different commit (changing the index and the working tree in the process).

**d)** You should avoid rewriting the history in public repositories as much as possible. If you already pushed the changes to a public repository you can, however, add a commit that reverts a previous commit.

Try this by using:

```
git revert <commit-id>
```

You can use **HEAD** as the **commit-id**, for example. This will revert the last commit by adding a new commit.

## 13. IMPROVING YOUR GIT BRANCHING

- Now it is time to test your brand new branching skills using Learn Git Branching ↗.
- You can also try this Git Visualization Tool ↗.