🚀 Architecture & Deployment

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Deploy a PHP application with SFTP

This guide describes how to deploy a PHP application over SFTP on a server with PHP and MySQL installed, using the PHP development server.

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📜 Legend

Parts of this exercise are annotated with the following icons:

❗	A task you MUST perform to complete the exercise
❓	An optional step that you may perform to make sure that everything is working correctly, or to set up additional tools that are not required but can help you
🏁	The end of the exercise
🏛️	The architecture of the software you ran or deployed during this exercise.
💥	Troubleshooting tips: how to fix common problems you might encounter

❗ Setup

Use the previous PHP Todolist Exercice. Clone the PHP Todolist Exercice on your local machine if you do not have it. Be sure to use a version with the three SQL queries implemented.

❗ Install MySQL

Connect to your server with SSH.

Update your package lists and install the MySQL database server:

```
$> sudo apt update

$> sudo apt install mysql-server
```

> 💎 **Tip**

> APT may prompt you to restart some services. See the troubleshooting section about 💥 Daemons using outdated libraries if necessary.

📚 Advanced Packaging Tool (APT) is the package manager for Ubuntu (and some other Linux distributions). We will not discuss this tool, but you can read more about it in the installation & upgrading section of the system administration cheatsheet.

APT should automatically start MySQL after installation. You can check this with the following command:

```
$> sudo systemctl status mysql
```

Secure your installation by running the `mysql_secure_installation` tool that comes with MySQL. It will ask you several questions to help you improve the security of your MySQL installation:

```
$> sudo mysql_secure_installation

Securing the MySQL server deployment.

Connecting to MySQL using a blank password.

VALIDATE PASSWORD PLUGIN can be used to test passwords
and improve security. It checks the strength of password
and allows the users to set only those passwords which are
secure enough. Would you like to setup VALIDATE PASSWORD plugin?

Press y|Y for Yes, any other key for No: y

There are three levels of password validation policy:

LOW    Length >= 8
```

```
MEDIUM Length >= 8, numeric, mixed case, and special characters
STRONG Length >= 8, numeric, mixed case, special characters and dictionary file

Please enter 0 = LOW, 1 = MEDIUM and 2 = STRONG: 1
Please set the password for root here.

New password: ***
Re-enter new password: ***

Estimated strength of the password: 100
Do you wish to continue with the password provided?(Press y|Y for Yes, any other 

By default, a MySQL installation has an anonymous user,
allowing anyone to log into MySQL without having to have
a user account created for them. This is intended only for
testing, and to make the installation go a bit smoother.
You should remove them before moving into a production
environment.

Remove anonymous users? (Press y|Y for Yes, any other key for No) : y
Success.

Normally, root should only be allowed to connect from
'localhost'. This ensures that someone cannot guess at
the root password from the network.

Disallow root login remotely? (Press y|Y for Yes, any other key for No) : y
Success.

By default, MySQL comes with a database named 'test' that
anyone can access. This is also intended only for testing,
and should be removed before moving into a production
environment.

Remove test database and access to it? (Press y|Y for Yes, any other key for No)
 - Dropping test database...
Success.
```

```
 - Removing privileges on test database...
Success.

Reloading the privilege tables will ensure that all changes
made so far will take effect immediately.

Reload privilege tables now? (Press y|Y for Yes, any other key for No) : y
Success.

All done!
```

❗ Install PHP

Here you will install the bare minimum:

- The PHP **F**astCGI **p**rocess **m**anager (FPM)
- The PHP MySQL extension

Simply run this command to install both:

```
$> sudo apt install php-fpm php-mysql
```

> 📚 📚 Traditionally, PHP is deployed using the Apache web server, which is a generic web server and reverse proxy but is also capable of executing PHP code. To simplify things in this exercise, we will not install Apache, but instead execute the PHP application directly from the command line using the simpler PHP development server.

❗ Use a real password

The `todolist.sql` file creates a `todolist` user with the password `change-me-now` by default. You should change the password to a more secure value. Make sure that the password you choose is strong enough per the minimum password requirements you chose when you secured the MySQL installation.

> 💎 **Tip**
>
> Need help choosing a good password? Don't use something that is hard to remember. You're better off using a passphrase (here's a French version).

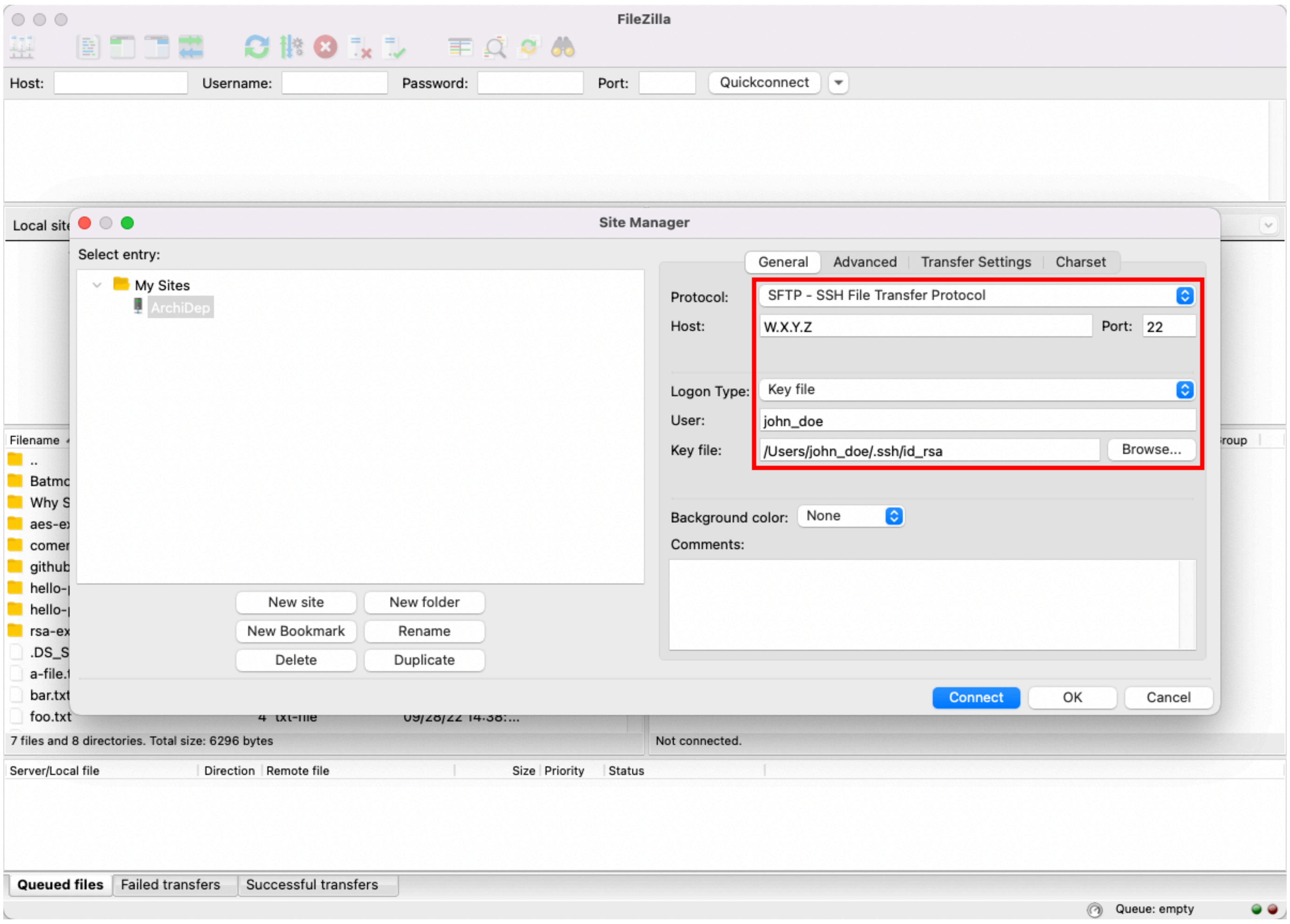
📚 It is good practice to create a different user and password for each application that connects to the MySQL database server. That way, if one of the applications is compromised, it cannot access or modify the databases of the other applications (provided you configured appropriate access privileges).

Notably, you should never use the MySQL `root` password to connect an application to its database. You, the system administrator, should be the only person who knows that password.

❗ Upload the application

On your local machine, use an SFTP client like FileZilla or Cyberduck to upload the application to the server.

Connect the SFTP client to your server using SSH public key authentication. In FileZilla, open the Site Manager and configure your connection like this:


Site Manager

Select entry:

My Sites
ArchiDep

Protocol: SFTP - SSH File Transfer Protocol
Host: W.X.Y.Z
Port: 22
Logon Type: Key file
User: john_doe
Key file: /Users/john_doe/.ssh/id_rsa
Background color: None
Comments:

You must select your **private key** (`id_rsa` and not `id_rsa.pub`) in FileZilla. The server you are connecting to has your public key. Just like when you use SSH on the command line, FileZilla will use your private key to prove to the server that you are the owner of your public key.

> 💎 **Tip**
>
> On Windows, you can toggle the display of hidden files in the View tab of the explorer to access your `.ssh` directory manually. On macOS, type `open ~/.ssh` in your Terminal or use the `Cmd-Shift-.` shortcut to display hidden files. On most Linux distributions, the file manager will have an option to show hidden files under its menu.

> 💎 **Tip**
>
> On Windows, FileZilla may ask you to convert your private key to another format. You can do so.

Once you are connected to your server with your SFTP client, copy the application to `/home/jde/todolist` (replacing `jde` with your Unix username).

In FileZilla, you can simply drag-and-drop the directory from your machine on the left to the server on the right. You can then rename it if necessary.

❗ Initialize the database

Connect to your server and go into the uploaded directory:

```
$> hostname
jde.archidep.ch

$> cd ~/todolist
```

Execute the project's SQL file to create the database and table (it will ask you for the MySQL `root` user's password you defined earlier):

```
$> sudo mysql < todolist.sql
```

📚 This uses the Unix redirection operator `<` to send the contents of the `todolist.sql` file into the standard input stream of the `sudo mysql` command. When provided with SQL queries on its input stream, the `mysql` command will connect to the MySQL server and execute them, then stop.

❓ Optional: make sure it worked

To make sure everything worked, you can check that the table was created in the MySQL database server. You do not have a phpMyAdmin web interface to administer the database server, since you are installing everything on your server yourself, and you did not install that.

Use the following command and SQL queries to first connect to the MySQL database server as the administrator (the MySQL `root` user), then display the `todo` table's schema:

```
$> sudo mysql

> connect todolist;

> show create table todo;
+-------+------------------------------------------------------+
| Table | Create Table                                         |
+-------+------------------------------------------------------+
| todo  | CREATE TABLE `todo` (
  `id` bigint(20) NOT NULL AUTO_INCREMENT,
  `title` varchar(2048) NOT NULL,
  `done` tinyint(1) NOT NULL DEFAULT '0',
  `created_at` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP,
  PRIMARY KEY (`id`)
) ENGINE=InnoDB AUTO_INCREMENT=3 DEFAULT CHARSET=latin1 |
+-------+------------------------------------------------------+
1 row in set (0.00 sec)
```

Everything went well if the table was created, since the creation of that table is the last step of the `todolist.sql` script.

You may exit the interactive MySQL console like most shells by typing `exit`.

❗ Update the configuration

Update the first few lines of the `index.php` file with the correct configuration:

```
define('BASE_URL', '/');
define('DB_USER', 'todolist');
define('DB_PASS', 'your-secret-password');
define('DB_NAME', 'todolist');
define('DB_HOST', '127.0.0.1');
define('DB_PORT', '3306');
```

> 💎 **Tip**
>
> The `index.php` file **on the server** must be modified. There are several ways you can do this:
>
> - Edit the file locally, then copy it to the server again using your SFTP client like FileZilla.
> - Edit the file directly on the server with `nano` or `vim`.
> - Some SFTP clients allow you to open a remote file in your local editor. In FileZilla, right-click a file, select View/Edit, then choose your favorite editor. Make your changes and save the file. FileZilla should automatically prompt you to upload the changes.

❗ Run the PHP development server

Also in the uploaded directory on the server, run a PHP development server on port 3000:

```
$> php -S 0.0.0.0:3000
```

> 📚 **More information**
>
> The `-S <addr:port>` option of the `php` command starts the built-in web server on the given local address and port.

> 💎 **Tip**
>
> You **must really use** `0.0.0.0` **for the** `php -S` **command, and not your server's IP address**. `0.0.0.0` is not an actual IP address; it is a special notation that tells the PHP development server to accept connections from any IP address.

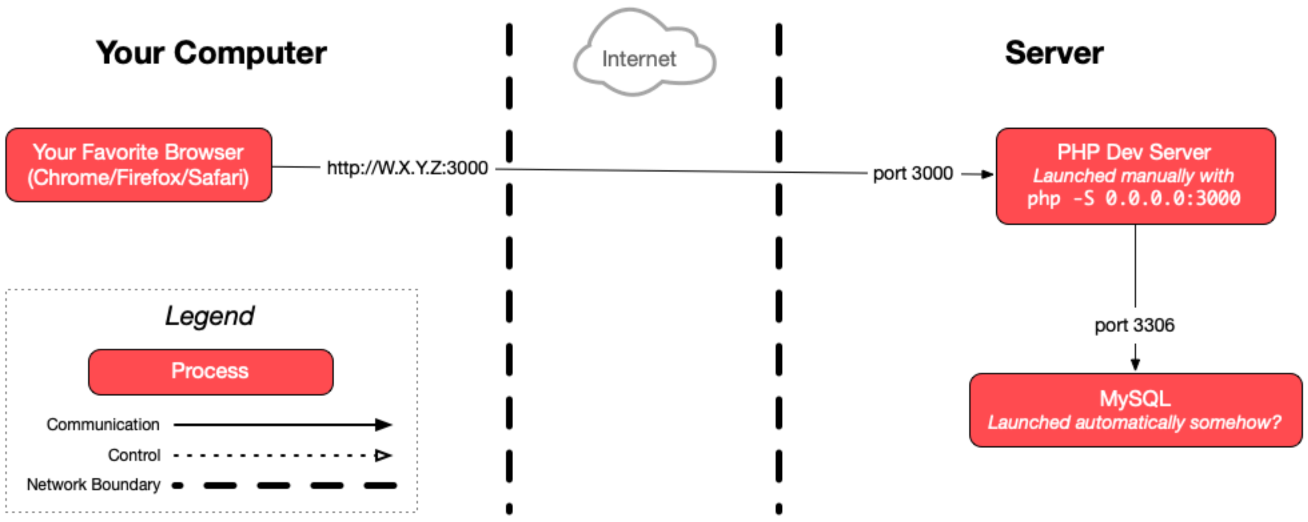
You (and everbody else) should be able to access the application in a browser at your server's IP address and the correct port (e.g. `http://W.X.Y.Z:3000`).

🏁 What have I done?

You have **deployed** a PHP application to a server running in the Microsoft Azure cloud.

The application is now publicly accessible by anyone on the Internet, at your instance's public IP address.

This is a simplified architecture of the main running processes and communication flow at the end of this exercise:



How to improve our basic deployment

The basic SFTP deployment of the PHP TodoList has several flaws which we will fix during the rest of the course:

- Transfering files manually through SFTP is slow and error-prone. We will use **Git** to reliably transfer files [from our central codebase][12factor-codebase] and easily keep our deployment up-to-date over time.
- Hardcoding configuration is a bad practice. We will use **environment variables** so that our application can be dynamically configured and deployed in any environment without changing its source code.
- Starting our application manually is not suitable for a production deployment. We will use a **process manager** to manage the lifecycle of our application: starting it automatically when the server boots, and restarting it automatically if it crashes.
- Accessing a web application through an IP address is not user-friendly. We will obtain a domain and configure its DNS zone file so that our application is accessible with a human-readable **domain name**.
- Using a non-standard port is not user-friendly either. We will run the application on **port 80 or 443** so that the end user does not have to specify a port in the browser's address bar.
- Running our application server directly on port 80 or 443 will cause a problem: only one process can listen on a given port at the same time. We need another tool to support **multiple production deployments on the same server**. That will be the job of a reverse proxy like Apache or nginx.
- Our application is not secure as indicated by the browser, because it is served over HTTP and not HTTPS. We will obtain a **TLS/SSL certificate** signed by a trusted certificate authority so that our application can be served over HTTPS and recognized as secure by browsers.
- The PHP Development Server is not meant to deploy applications in production environments. We will use the **FastCGI Process Manager** to perform a production-

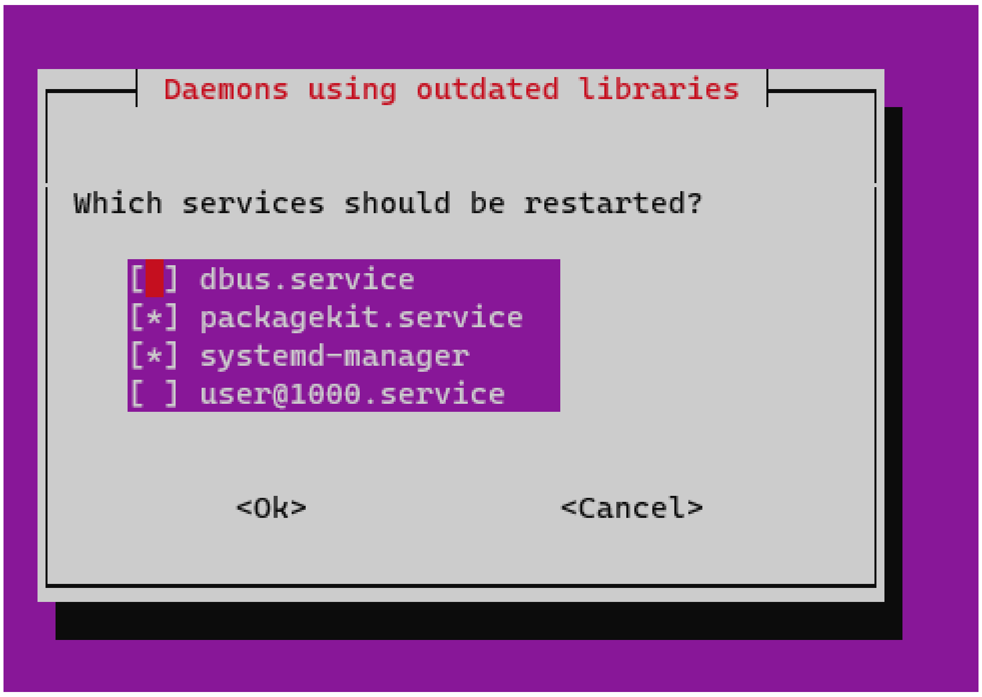
grade deployment, making our application more resilient and able to serve more clients concurrently.

💥 Troubleshooting

Here's a few tips about some problems you may encounter during this exercise.

💥 Daemons using outdated libraries

When you install a package with APT (e.g. MySQL), it *may* prompt you to reboot and/or to restart outdated daemons (i.e. background services):



```
Daemons using outdated libraries

Which services should be restarted?

    [ ] dbus.service
    [*] packagekit.service
    [*] systemd-manager
    [ ] user@1000.service

         <Ok>              <Cancel>
```

Simply select "Ok" by pressing the Tab key, then press Enter to confirm.

📚 This happens because most recent Linux versions have unattended upgrades: a tool that automatically installs daily security upgrades on your server without human intervention. Sometimes, some of the background services running on your server may need to be restarted for these upgrades to be applied.

Since you are installing a new background service (the MySQL server) which must be started, APT asks whether you want to apply upgrades to other background services by restarting them. Rebooting your server would also have the effect of restarting these services and applying the security upgrades.

💥 `SET PASSWORD has no significance` error when running `mysql_secure_installation`

You may encounter this error when `mysql_secure_installation` prompts you to set the password for the MySQL `root` user:

```
$> sudo mysql_secure_installation
...

Please set the password for root here.

New password:
Re-enter new password:

Estimated strength of the password: 50
Do you wish to continue with the password provided?(Press y|Y for Yes, any other
  ... Failed! Error: SET PASSWORD has no significance for user 'root'@'localhost'
      as the authentication method used doesn't store authentication data in the
      MySQL server. Please consider using ALTER USER instead if you want to
      change authentication parameters.
```

This is a bug that exists with the latest versions of `mysql_secure_installation` and recent Ubuntu installations (since July 2022). If you encounter this bug, `mysql_secure_installation` will be stuck in a loop. **Close your terminal window** and **connect to your server again** in another terminal.

Connect to the MySQL server:

```
$> sudo mysql
```

Your prompt should change to reflect the fact that you are connected to the MySQL server. You can then run the following query:

```
mysql> ALTER USER 'root'@'localhost' IDENTIFIED WITH mysql_native_password BY 'pas
```

Then exit the MySQL server:

```
mysql> exit
```

You can now re-run the original command:

```
$> sudo mysql_secure_installation
```

Once it is done, you can reconfigure MySQL to use passwordless socket authentication (it will ask you for the MySQL `root` password you have just defined):

```
$> sudo mysql -p
```

```
mysql> ALTER USER 'root'@'localhost' IDENTIFIED WITH auth_socket;
```

```
mysql> exit
```

If socket authentication is correctly configured, you should now be able to connect as the MySQL `root` user **without a password** with `sudo`:

```
$> sudo mysql
```

```
mysql> exit
```

This does not mean that anyone can access MySQL without a password. You can do so because you are using `sudo` and have just configured MySQL to use socket authentication for its `root` user.

There are two sets of users here:

- Your server has a number of Unix users (defined in `/etc/passwd`), one of them being the Unix `root` user.
- The MySQL database server has its own list of MySQL users independent of the system. There is also a MySQL user named `root` by default.

By default, the `mysql` command will attempt to connect as the MySQL user with the same name as the Unix user running the command. You can also specify which user to connect as with the `-u` (**u**ser) option:

```
$> whoami
jde

$> mysql              # connect to MySQL as the MySQL "jde" user (becau
                       # that is the name of the Unix user running the

$> mysql -u alice     # connect to MySQL as the MySQL "alice" user

$> sudo mysql         # connect as the MySQL `root` user (since you tem
                      # become the Unix "root" user when using "sudo")

$> sudo mysql -u root  # equivalent to the previous command
```

The first two `mysql` commands will probably fail:

```
ERROR 1045 (28000): Access denied for user 'jde'@'localhost' (using pass
ERROR 1045 (28000): Access denied for user 'alice'@'localhost' (using pa
```

This is because MySQL has no `jde` or `alice` users (unless you created them yourself). It may also be because you are trying to connect as a MySQL user who has a password. In this case, you should add the `-p` (**p**assword) option to have MySQL prompt you for the password when connecting (e.g. `mysql -u alice -p`).

If you followed the instructions above, you have replaced password authentication for the MySQL `root` user with the socket authentication method which delegates authentication to the Unix system. With this method, MySQL will compare the username of the Unix user running the `mysql` command with the MySQL user you are trying to connect as. It will only allow the connection if both are the same. In this case, since you are the Unix `root` user when using `sudo`, the MySQL server will allow a connection as the MySQL `root` user (you will not have to enter a password).

(Source of the solution: https://www.digitalocean.com/community/tutorials/how-to-install-mysql-on-ubuntu-22-04)

💥 Access denied for user 'root'@'localhost' (using password: NO)

If you see this error after running a `sudo mysql` command:

```
ERROR 1045 (28000): Access denied for user 'root'@'localhost' (using password: NO
```

It means that your MySQL server is configured to require a password for the `root` user. You have two choices:

- **Either** add the `-p` option to all `mysql` commands. It will then prompt you for the MySQL `root` password (that you defined when running `mysql_secure_installation`).

- **Or**, configure MySQL to use socket authentication for the `root` user (the following command will ask you for the MySQL `root` password you defined when running `mysql_secure_installation`):

  ```
  $> sudo mysql -p
  mysql> ALTER USER 'root'@'localhost' IDENTIFIED WITH auth_socket;
  mysql> exit
  ```

  If socket authentication is correctly configured, you should now be able to connect as the MySQL `root` user **without a password** with `sudo`:

  ```
  $> sudo mysql
  mysql> exit
  ```

See the explanations in the previous troubleshooting section for more information about socket authentication.

💥 Error when running `todolist.sql`

An error may occur when you execute the SQL queries in the `todolist.sql` script. For example, MySQL may tell you the `todolist` user's password in the script is not strong enough, depending on the settings you selected when securing the MySQL installation.

To start over from scratch, connect to the MySQL server as an administrator and type the following queries:

```
$> sudo mysql
> drop table todolist.todo;
```

```
> drop user todolist@localhost;
> drop database todolist;
```

> 💎 **Tip**
>
> Some of these commands may cause errors if the `todolist.sql` script could not execute entirely. For example, if the script could not create the `todolist` user and/or the `todo` table, the first `drop table todolist.todo;` query will fail with:
>
> `ERROR 1051 (42S02): Unknown table 'todolist.todo'`
>
> That's fine. Running the three queries will make sure you have nothing left that may have been created by the `todolist.sql` script, so you can start over with a clean state.

Once you have dropped everything, you can resume the exercise from the database initialization step.

💥 HTTP ERROR 500 error when trying to access the todolist in my browser

If you get an HTTP 500 error (which means an internal server error), look at the PHP development server logs in the terminal where you are running the `php -S 0.0.0.0:3000` command. You will probably see something like this:

```
$> php -S 0.0.0.0:3000
[Thu Oct 20 09:29:40 2022] PHP 8.1.2 Development Server (http://0.0.0.0:3000) sta
[Thu Oct 20 09:29:41 2022] 213.3.2.128:44496 Accepted
[Thu Oct 20 09:29:41 2022] PHP Fatal error:  Uncaught PDOException: SQLSTATE[HY00
Stack trace:
#0 /home/jde/todolist/index.php(17): PDO->__construct()
#1 {main}
  thrown in /home/jde/todolist/index.php on line 17
```

```
[Thu Oct 20 09:29:41 2022] 213.3.2.128:44496 [500]: GET / - Uncaught PDOException
Stack trace:
#0 /home/jde/todolist/index.php(17): PDO->__construct()
#1 {main}
  thrown in /home/jde/todolist/index.php on line 17
[Thu Oct 20 09:29:41 2022] 213.3.2.128:44496 Closing
[Thu Oct 20 09:29:41 2022] 213.3.2.128:44495 Accepted
```

If you see this `Access denied for user 'todolist'@'localhost' (using password: YES)` in the logs, it means that MySQL is not allowing the PHP todolist to open a MySQL connection as the `todolist` user. The `using password: YES` part indicates that a password is sent, but it is incorrect.

You may be using the wrong password. Make sure the `DB_PASS` constant at the top of the `index.php` file on the server contains the correct password. This must be the password that was in the `todolist.sql` file when you executed it.

> 💎 **Tip**
>
> If you do not remember the password, follow the troubleshooting instructions for an error running `todolist.sql` to re-create the database, user and password.

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