

Balancing Robots

guide for the hands-on experiences



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Instructions for installing the software: Arduino IDE

If you have not done so yet, download and install the latest Arduino IDE from <https://www.arduino.cc/en/Main/Software>, it should look like this:

Download the Arduino IDE

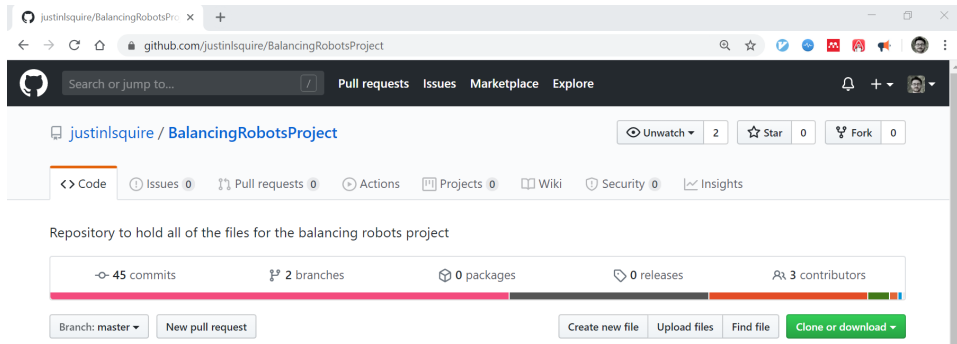


The screenshot shows the Arduino IDE download page. On the left, there is a teal circle with a white infinity symbol containing a minus and a plus sign. To its right, the text reads: **ARDUINO 1.8.13**, followed by a paragraph describing it as open-source software for Windows, Mac OS X, and Linux, written in Java and based on Processing. Below this, it states the software can be used with any Arduino board and refers to the 'Getting Started' page for installation instructions. On the right side of the page, there are links for 'Windows Installer, for Windows 7 and up', 'Windows ZIP file for non admin install', 'Windows app' (noting it requires Win 8.1 or 10), 'Mac OS X 10.10 or newer', and a list of Linux versions (32 bits, 64 bits, ARM 32 bits, ARM 64 bits). At the bottom right, there are links for 'Release Notes', 'Source Code', and 'Checksums (sha512)'.

Note that you might get a “Windows Security” message asking whether you would like to install the “Adafruit Industries LLC Ports” and “Arduino USB Driver” software too. In this case, install that as well.

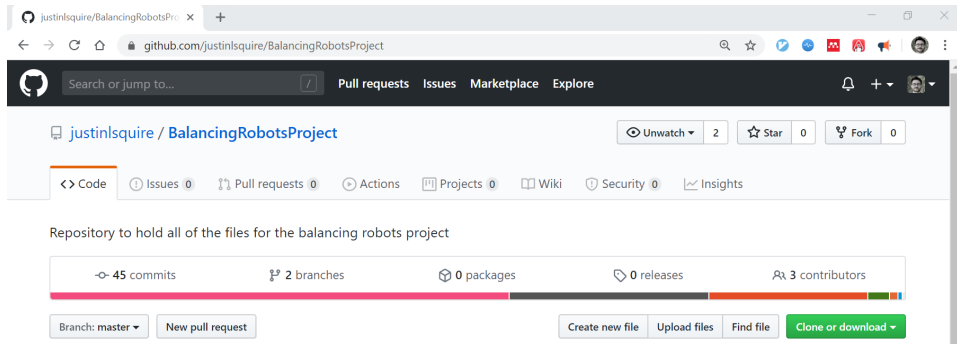
Instructions for installing the software: Balancing Robot Project Software

Go to `https://github.com/justinlsquire/BalancingRobotsProject`, it should look like this:



Instructions for installing the software: Balancing Robot Project Software

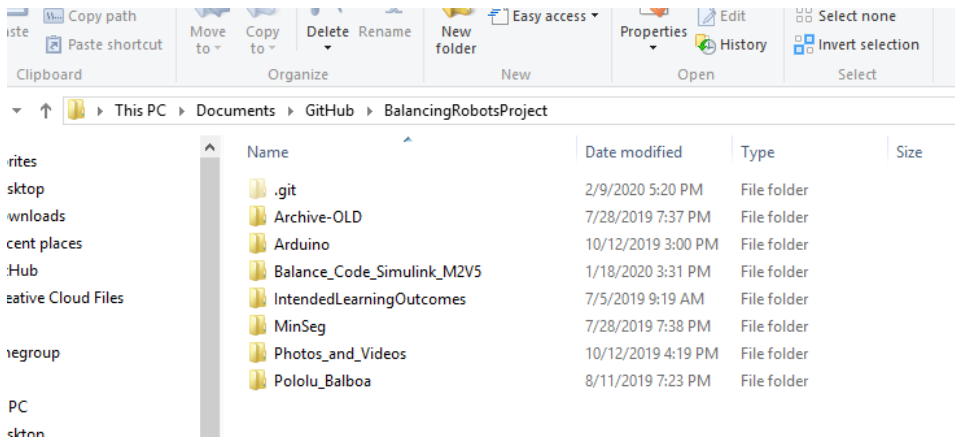
Download the software by clicking the “clone or download” button:



in any folder you prefer. Then unzip the downloaded file.

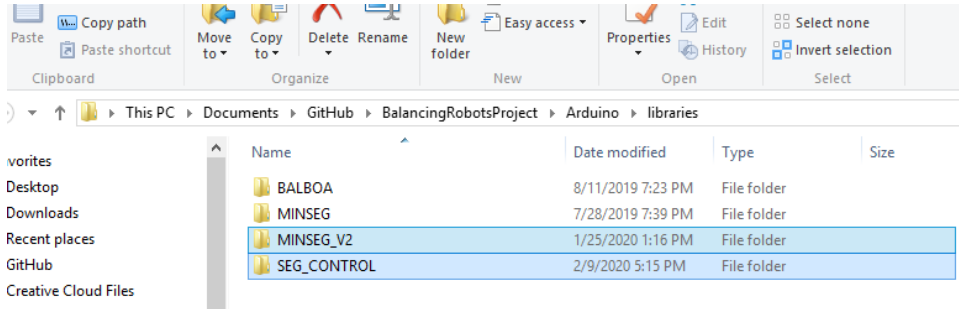
Instructions for installing the software: Balancing Robot Project Software

Open the unzipped file (sometimes called also “repository”) in your file explorer:



Instructions for installing the software: Balancing Robot Project Libraries

Go to the “Arduino” folder inside this just downloaded repository, then the “libraries” folder, then highlight and *copy* the two folders called “MINSEG_V2” and “SEG_CONTROL”:



Instructions for installing the software: Balancing Robot Project Libraries

Go to your Arduino Libraries folder (note that the default location for Windows is Documents → Arduino → Libraries. Sometimes is also C:\Program Files (x86) \Arduino \libraries) and paste the two folders there:

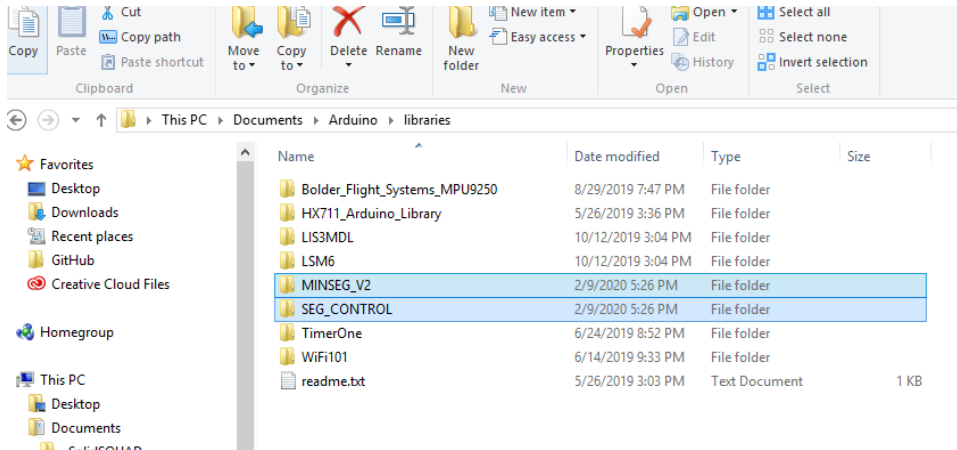


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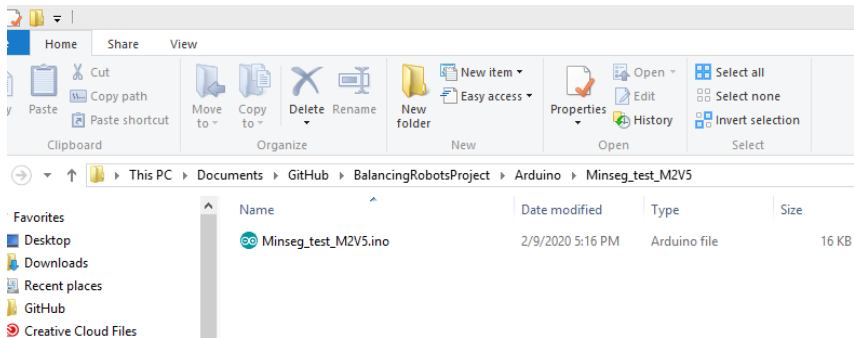
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Connecting the robot: Connect the hardware

- Add six AA batteries to the back of the robot.
- Use the usb cable to connect the robot to your computer.
- Switch the “Driver Enable” switch in the top left corner of the robot to “off”.

Connecting the robot: Open the file

Go back to the GitHub repository folder BalancingRobotsProject → Arduino → Minseg_test_M2V5, and then open the “Minseg_test_M2V5.ino” file in Arduino (it should be fine to just double click on it, since the extension “.ino” should now be associated to the Arduino IDE program)



If it is the first time that you open this type of file you may get some firewall alerts about javaw.exe. Allow access

Connecting the robot: Select the board

Go to Tools → Board and select “Arduino/Genuino Mega or Mega 2560”
(sometimes one may have only “Arduino Mega or Mega 2560”; that is ok too!)

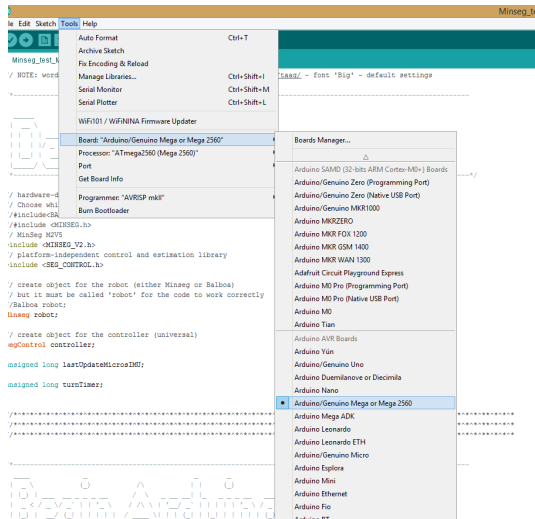


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Calibrating the sensors: Open the code

Find the right part of code for the calibration of the robot entitled Sensor calibration steps

```
217 //*****
218 // Sensor calibration steps
219 //*****
220
221 // 1) Raw average gyro values - leave robot untouched on any surface,
222 //    uncomment the line below, upload code, and watch serial monitor
223 //    to see the output - use this value to set robot.gx_raw_offset (in setup)
224 //Serial.println(robot.getGyroXAvg());
225
226 // comment the line out again before moving on.
227
228 // you can confirm that the gyro offset worked by uncommenting this line
229 //Serial.println(robot.gx*57.4);
230 // (it should be around 0 when the robot is sitting still on any surface)
231
232
233 // 2) Vertical orientation offset
234 //    uncomment the line below, upload code, and watch serial monitor while trying to
235 //    carefully hold the robot vertically balanced (gently using your fingers to maintain it
236 //    around the balance point)
237 //    use the value to set robot.orientationOffsetX (in setup)
238 //Serial.println(robot.getOrientationOffset()*100);
239
240 // comment the line out again before moving on.
241
```

The calibration routine is written out / explained in the code as well. So, we are basically going to follow these instructions step by step.

Calibrating the sensors: First step: raw offset

Uncomment line 224 (or search for the line in case it has moved) so that it reads `Serial.println(robot.getGyroXAvg());` (without `// !!`)

```
217 //*****
218 // Sensor calibration steps
219 //*****
220
221 // 1) Raw average gyro values - leave robot untouched on any surface,
222 //    uncomment the line below, upload code, and watch serial monitor
223 //    to see the output - use this value to set robot.gx_raw_offset (in setup)
224 Serial.println(robot.getGyroXAvg());
225
```

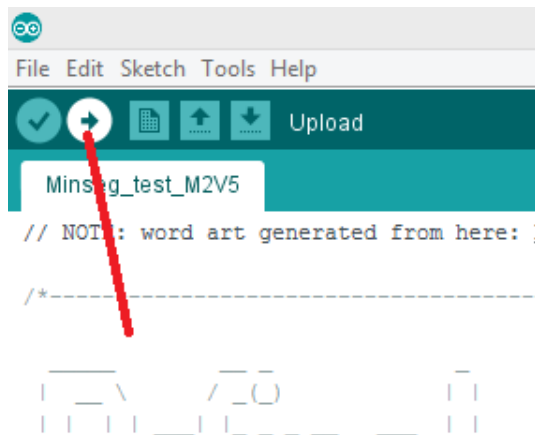
This will ensure that the raw data of the gyroscope can be read.

Calibrating the sensors: Put the Minseg down

Put the Minseg onto a flat surface and let it lay absolutely still.

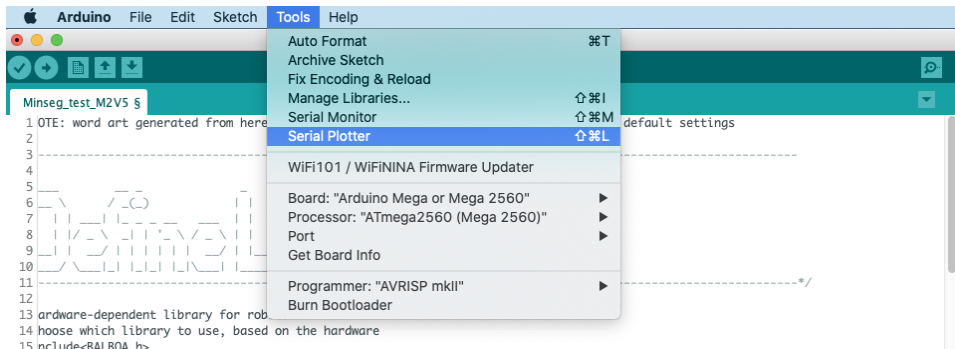
Calibrating the sensors: Upload the code

Click the “Upload” button to load the code to the MinSeg



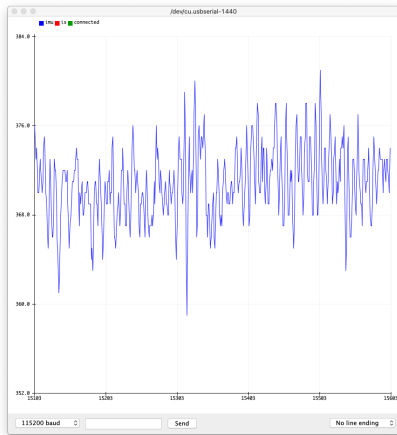
Calibrating the sensors: Open the Serial plotter

Open the serial plotter by selecting the appropriate item in Tools.



Calibrating the sensors: Observe the raw measurement

Observe the values / the curve and note down the average value. (Here: roughly 372)



Make sure to select “115200 baud” in the box at the bottom left of the plot window!

Calibrating the sensors: Set the raw offset

Comment line 224 again so that it reads

```
//Serial.println(robot.getGyroXAvg());.
```

Find the line of code setting the gyro offset, which reads

```
robot.gx_raw_offset = 373; // gyro offset in raw units
```

and replace the offset value with the average that you observed above.

```
73 // set these based on the true observed values from the sensors
74 // instructions will be done soon
75 robot.gx_raw_offset = 372; // gyro offset in raw units
76 controller.orientationOffsetX = -1.62; // vertical (balancing) orientation offset in radians
77
```

Calibrating the sensors: Test the raw offset

Test whether the setting of the raw offset is correct by uncommenting line 229 so that it reads `Serial.println(robot.gx*57.4);`

```
228 // you can confirm that the gyro offset worked by uncommenting this line
229 Serial.println(robot.gx*57.4);
230 // (it should be around 0 when the robot is sitting still on any surface)
231
```

upload the code to the Minseg, place it still on a flat surface and observe the values in the serial plotter.

If the calibration was successful, the plotted values should be around 0. Comment line 229 afterwards again.

Calibrating the sensors: Second step: orientation offset

Uncomment line 238 (or search for the line in case it has moved) so that it reads
`Serial.println(robot.getOrientationOffset()*100);` (without `// !!`)

```
233 // 2) Vertical orientation offset
234 //   uncomment the line below, upload code, and watch serial monitor while trying to
235 //   carefully hold the robot vertically balanced (gently using your fingers to maintain it
236 //   around the balance point)
237 //   use the value to set robot.orientationOffsetX (in setup)
238 Serial.println(robot.getOrientationOffset()*100);
239
```

NOTE: This plots the value times a factor of 100 (!!) to allow to see the usually small value in more detail / higher resolution.

Calibrating the sensors: Observe the orientation offset

Similar to observing the raw offset,

- save the code (ctrl-S)
- Upload the code to the Minseg.
- Open the serial plotter.
- Hold the Minseg carefully between your finger tips so that it balances!!
- Observe the value when the robot is still and balances and note the average value.
- In line 76, set `controller.orientationOffsetX` to the value you observed divided by 100 (!!)
- Comment line 238 again.
- Save the code again (ctrl-S)

Calibrating the sensors: Test the orientation offset

Test whether the setting of the orientation offset is correct by uncommenting line 243 so that it reads `Serial.println(controller.ex*57.4);`

```
242 // you can confirm that the offset worked by uncommenting this line
243 Serial.println(controller.ex*57.4);
244 // (it should be around 0 when the robot is vertical)
245
```

upload the code to the Minseg, hold it carefully so that it balances and observe the values in the serial plotter.

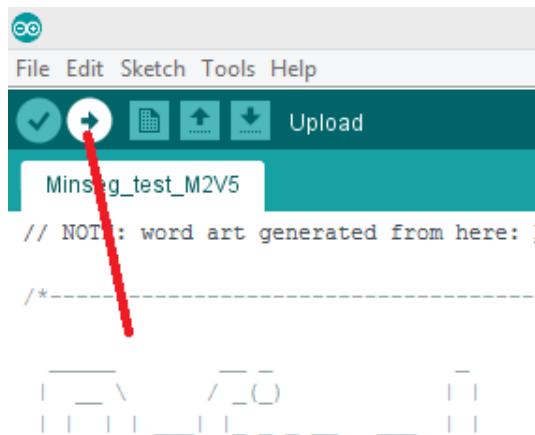
If the calibration was successful, the plotted values should be around 0. Comment line 243 afterwards again and save the code.

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Running the software: Upload the code including your calibrated values

Click the “Upload” button to load the code to the MinSeg



Running the software: See the robot balance!

Hold the robot upright and make sure the switches are set to “ON”, “BATT”, and “ON” from the top down - the robot should start balancing if everything went well!