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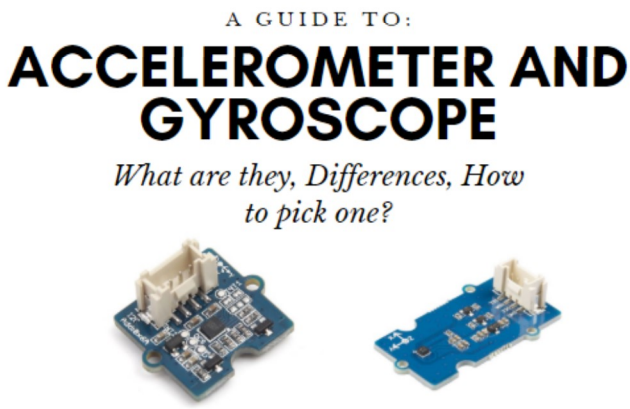
Accelerometer vs Gyroscope sensor, and IMU, how to pick one?

By Shawn (/blog/author/shawn/) 1 year ago

With the increasing popularity of MEMS accelerometer and gyroscope sensors for Arduino motion sensing, many are considering picking one up to kickstart their next project. However, with a plethora of options available, selecting one that's suitable may be a tough task to handle.



Before scrambling and worrying about how do I pick an accelerometer and gyroscope, you'll first need to know the differences between both.

In this guide, I'll be walking you through the following:

- What is an accelerometer?
- What is a gyroscope?
- What's the difference between accelerometer and gyroscope?
- How to choose an accelerometer?
- How to choose a gyroscope?
- Honourable mentions with IMU

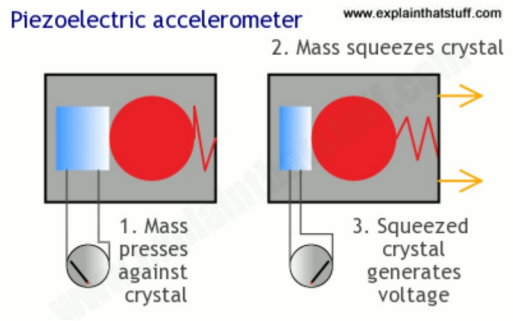
What is an Accelerometer?

Accelerometers are *electromechanical devices that measure acceleration, the rate of change in velocity of an object.* In other words, it's devices used to respond to any vibrations associated with movement.

How does an accelerometer work?

There are two ways where accelerometers work; Piezoelectric effect, and Change in Capacitance. Sounds confusing? It's relatively simple, here's how:

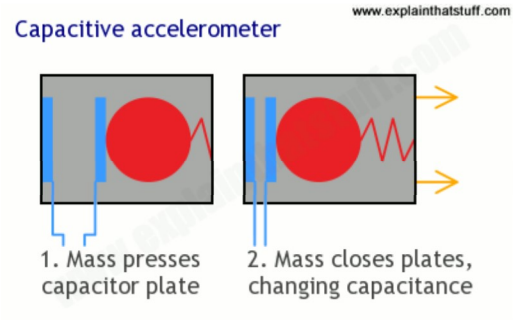
Piezoelectric effect:



Ref (https://www.explainthatstuff.com/accelerometers.html)

1. Accelerometers contain microscopic crystal structures, generating voltages when vibrations occur
2. Voltage generated will create a reading of how much acceleration are there

Change in Capacitance:



ref (https://www.explainthatstuff.com/accelerometers.html)

This method plays with the formula in finding acceleration. Since we know that Force = Mass x Acceleration, to find acceleration, it'll take the Force present / Mass of an object.

This is how the capacitance effect in a MEMS accelerometer works:

1. 2 capacitive plates are present
2. The mass of an object presses on one of the capacitor plates, changing the capacitance and allowing for the force to be measured
3. With force and mass of object known, acceleration is then measured

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MEMS Accelerometers

Accelerometers can be based on other operating principles, such as the microchip-packaged mems accelerometers. Mems accelerometers are designed for easy integration with Arduino or other microcontrollers these days, with common ones being the ADXL sensor series (popular ones being ADXL345, ADXL335).

With its miniaturized sensors, Mems accelerometers are applicable for IoT usages, low-power, industrial and automotive applications, healthcare, etc.

Applications of Accelerometers

Now that we've understood how accelerometer work, we'll take a look at what it's commonly used for. Here is the key list of applications:

- Compass/Map applications on your smartphone devices (iPhones, Andriod, etc.) through axis based sensing
- Tilt sensing; iPhone uses an accelerometer to sense whether the phone is being held in portrait or landscape mode
- Earthquake detection
- Fall sensing
- Medical devices such as artificial body parts
- Fitness trackers/wearables
- Games/applications that require motion sensing (Wii, Kinect, etc.)

Note: Accelerometers are most **commonly used** to detect position, velocity, vibration, and to determine orientation.

What is a Gyroscope?

Before we touch on the differences, we'll have to first understand what is a gyroscope. Gyroscope is a device used for measuring rotational changes or maintaining orientation. It's based on the principle of preserving angular momentum.

How does Gyroscope work?

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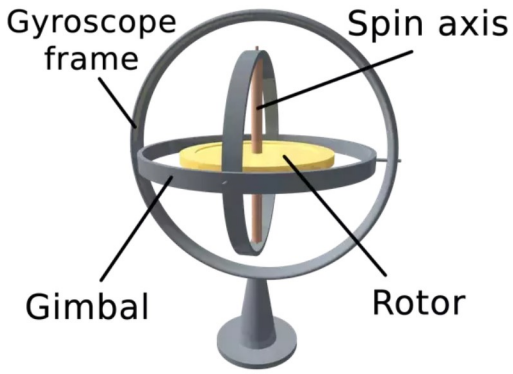

ref (https://www.quora.com/What-is-a-gyroscope-3?no_redirect=1)

A typical gyroscope contains a rotor that's suspended inside three rings called the gimbals.

It works through the precession effect, allowing gyroscopes to defy gravity when the spin-axis is rotated. This means that instead of falling over from the force of gravity, it automatically adjusts itself sideways.

For more on how Gyroscopes work, you can check this article out! (https://geekswipe.net/science/physics/how-gyroscopes-work-intuitive-explanation/)

Applications of Gyroscope

Understanding how it works is one thing, but what it is used for? Although dating back to the 18th century, Gyroscopes are still used now, with it becoming an integral part of navigational systems we commonly see nowadays:

- Aircrafts
- Space stations
- Stability in vehicles; motorcycles, ships
- Inertial guidance systems
- Consumer electronics through MEMS gyroscopes (Most mid-range to higher-end Andriod phones)

MEMS Gyroscope

You may be wondering, what is MEMS Gyroscopes? Aren't Gyroscopes just Gyroscopes?

MEMS Gyroscopes are small miniaturized sensors designed possible through integrating MEMS (Micro-Electro-Mechanical-System)

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technology into it. This allows for the functionality of gyroscopes to be utilized in a smaller package!

Similarly to MEMS accelerometers, with such technology, it allows for a lower cost, lower power, and applicability with your Arduino, Raspberry Pi, and more!

Accelerometer vs Gyroscope

Accelerometer and gyroscope difference:

For ease of understanding the difference between Accelerometer and Gyroscopes, I've provided a comparative table for illustration:

	Accelerometers	Gyroscopes
What it is	Electromechanical devices that measure acceleration Cannot distinguish rotation from acceleration	A device used for measuring rotational changes or maintaining orientation Unaffected by acceleration
Usage purpose	Measure linear acceleration based on vibration	Measure rate of rotation and angular position around a particular axis
Applications	Commonly found and more applicable in consumer electronics	Commonly found and more applicable in aircrafts, aerial vehicles

All in all, although both devices have their notable differences, many appliances out there still benefit from the presence of both sensors. It ultimately comes down to what applications you're looking for.

How to choose an Accelerometer and Gyroscope?

How to choose an Accelerometer?

To help you pick a suitable MEMS accelerometer for your Arduino, here are the important criteria you should consider!

Criteria	Recommendations/Considerations
Range	**For precise readings:** Pick a smaller full-scale range as it'll give you a more precise reading due to a more sensitive output **Consider acceleration ranges that fit your projects.**

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Interface	**Easiest interface to work with:** Analog interface, as analog-to-digital converters (ADCs) are implemented in most microcontrollers **For producing fixed frequency:** PWM interface, produces a square wave with fixed frequency but duty cycle of the pulse varies with sensed acceleration **Most features and lesser noise:** Digital interface, features either SPI or I^2C serial interface but may be difficult to integrate with microcontroller
Axes	Three-axis accelerometers, most common and not significantly more costly as compared to one or two axis accelerometers
Power Usage	Required current consumption of an accelerometer is usually in the 100s of µA range Take into consideration required power.
Bonus Features	Picking newer models of accelerometers may be a better choice as they include more bonus features such as: Selectable measurement ranges Sleep Control 0-g detection Tap sensing

Which Accelerometer to buy?

Based on the criteria above, these are my recommended accelerometers available at Seeed!

Grove – 3-Axis Digital Accelerometer ±16g Ultra-low Power (BMA400) (https://www.seeedstudio.com/Grove-3-Axis-Digital-Accelerometer-16g-Ultra-low-Power-BMA400.html?utm_source=blog&utm_medium=blog) (https://www.seeedstudio.com/Grove-3-Axis-Digital-Accelerometer-16g-Ultra-low-Power-BMA400.html?utm_source=blog&utm_medium=blog)

Based on the BMA400 sensor, this 3-Axis Digital Accelerometer is a 12-bit triaxial acceleration sensor with smart-chip motion and position-triggered interrupt features. Detecting movement posture such as Walking, Running, Standing still all with ease!

Criteria Evaluation:

Criteria	**Evaluation**
Range	±2g, ±4g, ±8g, ±16g
Interface	I2C
No. of Axes	3-Axis
Power Usage	18uA @5V, 14uA @3.3V
Bonus Features	Auto-low power/wakeup Activity/In-activity Step Counter Activity Recognition (Walking, Running, Standing still) Orientation detection Tap/Double Tap

Interested to know more? More information alongside this accelerometer Arduino guide is available on our wiki page here! (https://www.seeedstudio.com/Grove-3-Axis-Digital-Accelerometer-16g-Ultra-low-Power-BMA400.html)

ADXL 3-Axis Accelerometers series

Apart from the above BMA400 based Accelerometer, the popular ADXL series is available for purchase here at Seeed as well! We offer the following 3-axis ADXL Accelerometers for your consideration:

Product	Measurement Range	Interface	Power Consumption	Bonus Features

Grove – 3-Axis Analog Accelerometer ±20g (ADXL356B) (https://www.seeedstudio.com/Grove-3-Axis-Analog-Accelerometer-20g-ADXL356B-p-4004.html?utm_source=blog&utm_medium=blog)	±10 ±20g	Analog	measurement mode:150 µA standby mode:21 µA	Low, drift, low noise; ideal for wireless condition monitoring A hermetic package that offers excellent long-term stability 0g offset vs. temperature (all axes): 0.75 mg/°C maximum
Grove – 3-Axis Analog Accelerometer ±40g (ADXL356C) (https://www.seeedstudio.com/Grove-3-Axis-Analog-Accelerometer-40g-ADXL356C-p-4006.html?utm_source=blog&utm_medium=blog)	±10g ±40g	Analog	measurement mode:150 µA standby mode:21 µA	Low, drift, low noise; ideal for wireless condition monitoring A hermetic package that offers excellent long-term stability 0g offset vs. temperature (all axes): 0.75 mg/°C maximum

Grove – 3-Axis Digital Accelerometer ±40g (ADXL357) (https://www.seeedstudio.com/Grove-3-Axis-Digital-Accelerometer-40g-ADXL357-p-4005.html?utm_source=blog&utm_medium=blog)	±10g@51200 LSB/g ±20g@25600 LSB/g ±40g@12800 LSB/g	Digital I2C	measurement mode:200μA	Low drift, low noise, low power A hermetic package that offers excellent long-term stability 0g offset vs. temperature (all axes): 0.75 mg/°C maximum Support FIFO(96*21-bit)
Grove – 3-Axis Digital Accelerometer ±200g (ADXL372) (https://www.seeedstudio.com/Grove-3-Axis-Digital-Accelerometer-200g-ADXL372-p-4003.html?utm_source=blog&utm_medium=blog)	±200g	Digital I2C	measurement mode:22μA	Deep embedded FIFO tominimize host processor load Selectable oversampling ratio and bandwidth

The Grove – 3-Axis Analog Accelerometer ±20g (ADXL356B) (https://www.seeedstudio.com/Grove-3-Axis-Analog-Accelerometer-20g-ADXL356B-p-4004.html?utm_source=blog&utm_medium=blog) and Grove – 3-Axis Digital Accelerometer ±200g (ADXL372) (https://www.seeedstudio.com/Grove-3-Axis-Digital-Accelerometer-200g-ADXL372-p-4003.html?utm_source=blog&utm_medium=blog) are currently out of stock but do keep a lookout when it's restocking by subscribing or consider the ADXL356C and ADXL357!

How to choose a Gyroscope?

Now that you've understood how to select a suitable accelerometer, here are the criteria for you to help you choose a Gyroscope with ease!

Criteria	Considerations/Recommendations
Range	When picking a Gyroscope, ensure the maximum range of the gyro doesn't exceed the maximum angular velocity you're looking to measure Similarly to accelerometer interfaces, picking gyroscopes with analog output will result in the easiest integration with your microcontroller
Interface	However, picking a Gyro with a digital interface is an appealing option since it tends to come with more features
Number of Axes	You wouldn't have to worry much about this criterion as most gyroscopes on the market feature analog Gyros are available in 1, 2, or 3-axis, where you'll have to consider which of these three will the Gyro measure since rotation will be affected Some 2-axis gyro measures Y and Z axes while others measure Y and X axes
Power Usage	To avoid over/under powering, check how much power the gyroscope will consume if your project runs by battery
Bonus Features	Gyroscopes tend not to offer much bonus features apart from temperature output If there are bonus features, it would be a plus point!

Which Gyroscopes to buy?

Based on the criteria above, these are my recommended gyroscopes to buy!

> Note: The following recommendations are Gyroscopes integrated alongside an accelerometer, allowing for functionalities of both in just one module!

Grove – 6-Axis Accelerometer&Gyroscope (https://www.seeedstudio.com/Grove-6-Axis-Accelerometer-Gyroscope.html?utm_source=blog&utm_medium=blog)

Based on the LSM6DS3 chip, this 6-Axis Accelerometer&Gyroscope is a cost-effective option with detailed SDK for easier programming with your Arduino!

Criteria Evaluation:

Criteria	Evaluation
Range	Gyro: ±125, ±245, ±500, ±1000, ±2000 degree per seconds(dps) Accelerometer: ±2/±4/±8/±16 g full scale leaner acceleration
Interface	I2C
No. of Axes	3-Axis gyroscope 3-Axis Accelerometer
Power Usage	Combo normal mode: 0.9 mA Combo high-performance mode: 1.25 mA
Bonus Features	_

Interested to find out more? More information alongside this gyroscope Arduino guide is available on our wiki page here! (http://wiki.seeedstudio.com/Grove-6-Axis_AccelerometerAndGyroscope/)

Grove – 6-Axis Accelerometer&Gyroscope (BMI088) (https://www.seeedstudio.com/Grove-6-Axis-Accelerometer-Gyroscope-BMI088.html?utm_source=blog&utm_medium=blog)

Based on the BOSCH BMI088 Gyroscope,
this 6-Axis Accelerometer&Gyroscope option is designed for drones, robotics, and industrial applications with the capability of handling challenging performance requirements!

Criteria Evaluation:

Criteria	Evaluation
Range	**Gyroscope:** ±125°/s @262.1 LSB/°/s ±250°/s @131.1 LSB/°/s ±500°/s @65.5 LSB/°/s ±1000°/s @32.8 LSB/°/s ±2000°/s @16.4 LSB/°/s **Accelerometer:** ±3g @10920 LSB/g ±6g @5460 LSB/g ±12g @2730 LSB/g ±24g @1365 LSB/g
Interface	I2C
No. of Axes	16bit triaxial gyroscope 16bit triaxial accelerometer
Power Usage	Operating voltage: 3.3V / 5V Low power consumption based on gyroscope used
Bonus Features	Low spectral noise

Interested to find out more? More information alongside this gyroscope Arduino guide is available on our wiki page here! (http://wiki.seeedstudio.com/Grove-6-Axis_Accelerometer%26Gyroscope%28BMI088%29/)

Honourable mentions

Gyroscope accelerometer magnetometer sensor (IMU)

Accelerometers and Gyroscopes are great options to get you started with motion sensing, but if you were to dive deeper and explore other options, you'll find yourself with Inertial Measurement Units (IMUs).

IMUs are essentially Accelerometers + Gyroscopes + Magnetometer sensors, making it a complete package capable of easily calculating orientation, position, and velocity!

Here at Seeed, we carry IMUs for your selection as well, here are some to consider!

Grove – IMU 9DOF v2.0 (https://www.seeedstudio.com/Grove-IMU-9DOF-v2-0.html?utm_source=blog&utm_medium=blog)

Want to get started with an IMU? The Grove – IMU 9DOF is a great place to start!

Packed with a 3-axis gyroscope, a 3-axis accelerometer, and a 3-axis magnetometer, it's a 9-axis motion tracking module based on MPU-9250 (http://www.seeedstudio.com/blog/2019/12/09/getting-started-with-mpu-9250-arduino-guide/).

Its features include:

- Ultra-low power, low voltage
- Wide Detecting Range
- Internal Digital Motion Processing™ (DMP™) engine supports advanced MotionProcessing and low power functions such as gesture recognition using programmable interrupts
- Self-test function
- Digital-output 3-Axis angular rate sensors (gyroscopes) with a user-

programmable full-scale range of ±250, ±500, ±1000, and ±2000°/sec
- Digital-output 3-Axis accelerometer with a programmable full-scale range of ±2g, ±4g, ±8g, and ±16g
- Digital-output 3-Axis accelerometer with a full-scale measurement range is ±4800μT

Interested to find out more? You can head to the product page for more! (https://www.seeedstudio.com/Grove-IMU-9DOF-v2-0.html)

Grove – IMU 10DOF v2.0 (https://www.seeedstudio.com/Grove-IMU-10DOF-v2-0.html?utm_source=blog&utm_medium=blog)

Need a substantial upgrade from the previous recommendation? The Grove – IMU 10DOF v2.0 provides a total of 10 axes of data for you, way more applications and better performance!

Based on the new and improved Bosch BMP280 and MPU-250, alongside a Digital Motion Processor (DMP) in a 3*3*1mm package, this IMU is not only small but consumes way less power!

- For more information on the MPU-9250 (https://raw.githubusercontent.com/SeeedDocument/Grove-IMU_10DOF/master/res/MPU-9250A_Product_Specification.pdf) and BMP280 (https://github.com/SeeedDocument/Grove-IMU_10DOF_v2.0/raw/master/res/BMP280-Datasheet.pdf), do refer to the respective datasheets

Its features include:

- Digital-output X-, Y-, and Z-Axis angular rate sensors (gyroscopes) with a user-programmable full-scale range of ±250, ±500, ±1000, and ±2000°/sec
- Digital-output 3-Axis accelerometer with a programmable full-scale range of ±2g, ±4g, ±8g, and ±16g
- Digital-output magnetometer with a full-scale range of ±4800uT

- Temperature measurement with ±1.0°C accuracy
- Barometric pressure measurement range 300 – 1100 hPa with ±1.0 hPa accuracy

Interested to find out more? You can head to the product page for more! (https://www.seeedstudio.com/Grove-IMU-10DOF-v2-0.html?utm_source=blog&utm_medium=blog)

Summary

That's all for today's guide on accelerometers, gyroscopes, and picking a suitable one. With the increasing popularity of both, it's indeed time to pick one up for yourself! The suitable one!

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Make a Universal Arduino IR Remote with Seeeduino XIAO! (/blog/2021/02/20/make-a-universal-arduino-ir-remote-with-seeeduino-xiao/)

Build an MQTT Intercom with Wio Terminal (with Code!) (/blog/2021/02/19/build-an-mqtt-intercom-with-wio-terminal-with-code/)

A Closer Look at MEMS Technologies and Applications in 2021 (/blog/2021/02/18/a-closer-look-at-mems-technologies-and-applications-in-2021/)

Seeeduino XIAO 2021 Recap & Update! (/blog/2021/02/18/seeeduino-xiao-2021-recap-update/)

7 Most Popular PCB Testing Methods During Manufacturing and Assembly (/blog/2021/02/18/7-most-popular-pcb-testing-methods-during-manufacturing-and-assembly/)

Wio Terminal: Arduino Smart Doorbell (with Code!) (/blog/2021/02/08/wio-terminal-arduino-smart-doorbell-with-code/)

Seeed Fusion Open Parts Library for PCBA