How Smartphone Sensors Work

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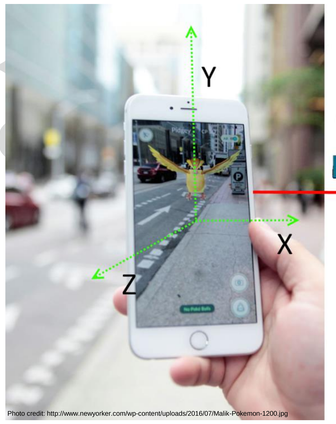

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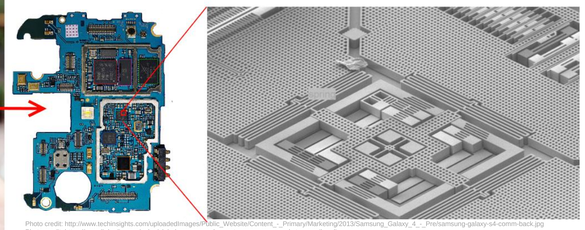
MEMS Sensors: Microelectromechanical Systems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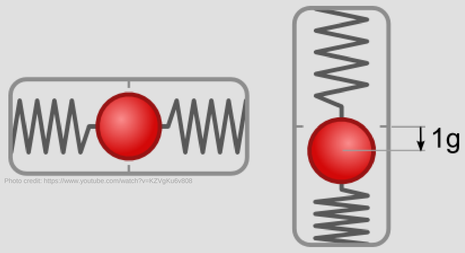
Inside your phone is a chip with a sensor the width of a human hair (~80 microns) that measures how your phone accelerates

How your phone knows how it **moves**, how it's **oriented**, and what **direction** it's facing.

Accelerometers: How is the phone accelerating?



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Physical Principle: ***F = ma F = kd***

When the phone accelerates, the force from the acceleration displaces a spring.

Measure how far the spring moved (d), multiply it by the spring stiffness (k), and divide by the mass that moved (m), and you've measured acceleration!

MEMS: Doing it in a tiny chip

Inside a small chip in your phone, the mass and the springs are cut from silicone. When the mass moves, small arms get closer to fixed plates with electrical charge.

The size of this gap changes how much electrical charge the plates can store (their capacitance). A circuit can measure this to calculate how far the mass moved. With this, it can calculate the acceleration which caused the motion!

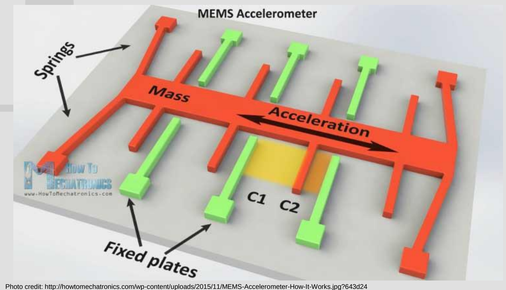

Photo credit: http://howtomechatronics.com/wp-content/uploads/2015/11/MEMS-Accelerometer-How-It-Works.jpg?643d24

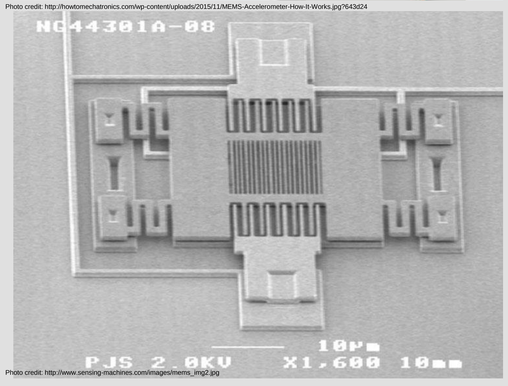

Photo credit: http://www.sensing-machines.com/images/mems_img2.jpg

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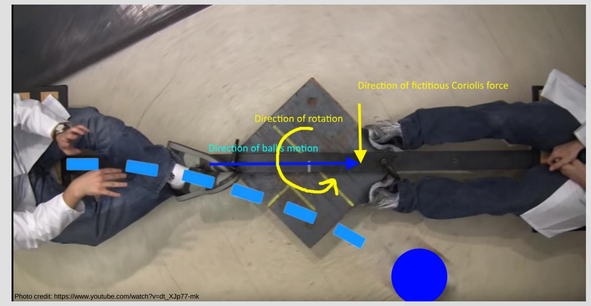
Gyros: How fast is the phone rotating?

Physical Principle: ***Coriolis Effect***

A ball thrown from a rotating platform looks as if there's a force acting on it to curve its path (even though it's actually moving straight). This fictitious force is the Coriolis Effect.

The apparent force is: $F = -2m\omega v$ **where v is the ball velocity, m is its mass, and** ω **is the rotational velocity.**



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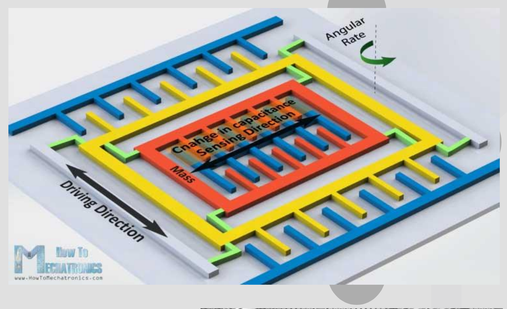
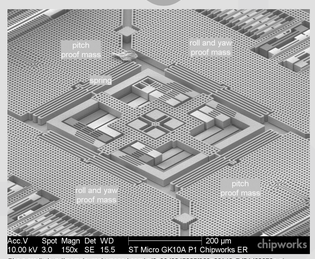
MEMS: Doing it in a tiny chip

Inside a small chip in your phone, a mass vibrates back and forth in the driving direction to produce a linear motion.

If your phone rotates, the Coriolis effect will move the vibrating mass perpendicular to how it was moving before.

Just like the accelerometer, small sensing arms get moved when that happens, changing the capacitance of fixed plates. This lets the circuit calculate F in the above equation (the Coriolis Force). Since the mass and velocity due to vibration are known, the circuit can calculate the rotational velocity!





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