How does GPS work?

KS2 KS3 Ages 9-14 ⏰ 4 min read

GPS stands for Global Positioning System. It's a network of 31 satellites orbiting Earth about 20,200km above the surface, each continuously broadcasting a radio signal containing one piece of information: exactly what time it is and where the satellite is right now. Your phone uses those signals to figure out where *it* is. The maths is elegant.

Triangulation from satellites

Radio signals travel at the speed of light. By measuring how long a signal took to arrive from a satellite, your GPS receiver can calculate how far it is from that satellite — distance equals speed multiplied by time. One satellite gives you a sphere of possible locations. A second satellite narrows it to a circle. A third satellite narrows it to two points (usually one of which is obviously wrong — in space or underground). A fourth satellite pins down your exact position in three dimensions.

Imagine you're blindfolded in an unfamiliar city. Someone calls you and says "I'm 500 metres away." That could be anywhere in a huge circle around them. A second person calls: "I'm 300 metres away." Now you're at the intersection of two circles — still two possible spots. A third person calls from 400 metres — and there's only one point that's 500m from person 1, 300m from person 2, AND 400m from person 3. That's you. GPS satellites are those callers, and the distances are calculated using signal travel time instead of guessing.

Why does GPS need such precise clocks?

Light travels 30cm in one nanosecond (one billionth of a second). An error of just one microsecond (one millionth of a second) in timing introduces 300 metres of position error. GPS satellites carry atomic clocks accurate to one nanosecond. Your phone's clock is far less accurate, which is why the fourth satellite is needed — it's used to correct your receiver's clock error as well as to fix your position.

What's the civilian accuracy?

Modern consumer GPS is typically accurate to 2–5 metres. The US military, which operates the GPS system, has access to more precise signals. Augmentation systems (like the European Galileo network) can increase precision to under a metre for applications like precision agriculture and autonomous vehicles. GPS has become so fundamental to modern life — not just navigation, but timing signals for financial transactions, mobile networks, and power grids — that a GPS outage would be genuinely catastrophic.