

Why does the Moon not fall onto Earth?

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The Moon is falling. What it usually avoids is collision. Gravity continually changes its motion, but that motion already includes a large sideways component. The resulting path bends around Earth rather than leading directly into it. An orbit is sustained motion under gravity, not a place where gravity has stopped working.

That answer is familiar enough to become another slogan. To understand it, we need to separate three things that everyday language often combines: acceleration, the shape of a path and the sensation of weight. A body can accelerate without speeding up, fall without approaching the ground monotonically, and feel weightless while gravity strongly affects its trajectory.

1. Falling does not specify the whole trajectory

Release an object with no sideways velocity relative to Earth's centre, and the idealized gravitational trajectory is radial. Give it a sideways velocity, and its later positions depend on that velocity as well as on gravity. The force specifies how velocity changes; it does not erase the velocity the object already has.

For a circular orbit in the simple model of a small satellite around a spherical Earth, gravitational acceleration is GM/r^2 . Here G is the gravitational constant, M Earth's mass and r distance from its centre. Circular motion requires an inward acceleration v^2/r . Equating the two gives $v = \sqrt{GM/r}$. This is a condition on motion, not a balance between inward gravity and a second outward physical force in an inertial frame.

The distinction matters. Two opposite forces that exactly cancelled would give zero acceleration. A circular orbit has nonzero acceleration because the direction of velocity continuously changes. Its speed may remain constant while its velocity does not. NASA's explanation of orbital microgravity makes the essential observational point: gravity remains substantial at spacecraft altitudes, and orbiting objects are in free fall [1].

2. What a circular calculation does and does not predict

Consider an explicitly hypothetical spherical planet with gravitational parameter $GM = 4.0 \times 10^{14} \text{ m}^3/\text{s}^2$ and an orbit of radius $r = 4.0 \times 10^8 \text{ m}$. The circular speed is 1,000 m/s. The inward acceleration is 0.0025 m/s^2 . Dividing the circumference $2\pi r$ by the speed gives a period of about 29.1 days.

These are chosen inputs, not a fit to observations of the Moon. The calculation shows that a small continuous acceleration can produce a very large curved path. There is no requirement for the acceleration at that distance to resemble the much larger acceleration of a falling object near Earth's surface.

The real lunar orbit is not a perfect circle, Earth is not fixed, and the Sun also affects the motion. In an isolated two-body treatment, both bodies orbit their common centre of mass. The relative orbit uses $G(M + m)$, where m is the Moon's mass, rather than assuming one body literally remains motionless. More detailed predictions add perturbations and Earth's actual mass distribution.

NASA gives the Moon's average distance as about 384,400 kilometres [2]. That number is a property inferred from observations; the hypothetical example above is a model exercise. Their proximity in scale should not be mistaken for an independent precision test. A

genuine test must compare predicted positions and times with measured ones, with uncertainties and corrections stated.

3. Sideways motion is necessary, but not every sideways speed gives a safe orbit

For a circular orbit, the required speed is fixed by the radius in this model. Other initial velocities can produce elliptical trajectories, escape trajectories or paths that intersect the planet. Saying that something has sideways motion is therefore insufficient to establish that it will keep orbiting without collision.

Angular momentum helps organize these possibilities. In an ideal central gravitational field, the torque about the centre is zero, so angular momentum is conserved. That constraint and the energy together determine the possible orbit. An ellipse generally involves both changing speed and changing distance; circular motion is a special case.

There is also no need for an engine to provide a continuous forward push in the ideal orbit. A tangential force would change the motion. Gravity supplies the inward acceleration that curves it. Real spacecraft may nevertheless need manoeuvres because of atmospheric drag, perturbations or operational requirements. The ideal model is useful precisely because its assumptions identify what additional effects must be examined.

4. Why falling objects can feel weightless

Stand on a scale and the surface pushes on you. The scale responds to that support force. Let the scale and your body fall together, and the support can become very small even though both continue accelerating gravitationally. NASA describes the same shared fall for an astronaut, spacecraft and released object [1].

This separates gravitational acceleration from apparent weight. In relativity, the acceleration registered by an ideal freely carried accelerometer is called proper acceleration. An ideal freely falling instrument reads zero locally; an instrument resting on a supporting surface does not. One need not interpret that zero as a claim that the surrounding gravitational field has vanished.

A finite spacecraft is not an exact point. Small gravity gradients, vibration and other disturbances can produce relative accelerations inside it. “Microgravity” consequently describes an environment with small residual effects, rather than a universal numerical promise for every location and experiment. Weightlessness is approximate in practical settings and local in its physical interpretation.

An orbiting astronaut is not held up by a floor the way a standing person is. The astronaut and vehicle follow very similar gravitational trajectories. What they share is their fall, which explains why the astronaut does not continually drop towards the cabin floor.

5. What observation adds to the explanation

Tracking positions over time establishes that the Moon follows a curved path and changes its distance from Earth. A successful gravitational model must reproduce that pattern, not simply draw a plausible circle. Measurements at many times constrain a trajectory much more strongly than a single picture does.

Likewise, an accelerometer inside a falling apparatus and an external measurement of its changing position address different quantities. Their different readings are not a contradiction. One measures acceleration relative to a chosen coordinate description; the other detects the departure from local free fall caused by support or other nongravitational forces.

The elementary orbit calculation is secure within its assumptions, but it does not specify every detail of lunar motion. Those details require a more complete dynamical model and observational data. There is no uncertainty about whether the Moon's orbit means gravity is absent: that interpretation fails at the level of the mechanism itself.

The Moon avoids Earth because its velocity and gravitational acceleration produce an orbit that does not intersect Earth's surface. Its nearly repeated face is a different question, involving the Moon's rotation, addressed in “Why does the Moon show us nearly the same face?” Keeping those questions separate prevents the geometry of an orbit from being mistaken for an explanation of tidal locking.

References

- [1] NASA Glenn Research Center. What Is Microgravity?
<https://www.nasa.gov/centers-and-facilities/glenn/what-is-microgravity/> (accessed 5 October 2026).
- [2] NASA Science. Moon Facts. <https://science.nasa.gov/moon/facts/> (accessed 5 October 2026).