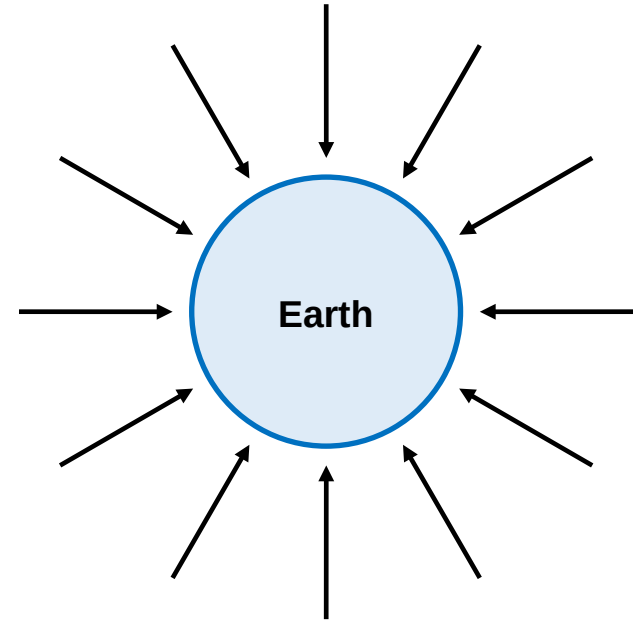


Essential Question

Why doesn't the Moon fall down to Earth?

Gravitational Field

- Mass creates a field around it
- Field lines point toward the mass
- Closer lines = stronger field



field lines point toward the mass

Field Strength

$$g = F / m$$

g

field strength (N/kg)

F

gravitational force (N)

m

mass (kg)

Earth's surface: $g = 9.8 \text{ N/kg} = 9.8 \text{ m/s}^2$

Weaker with Distance

- $g = GM/d^2$
- M : mass of the planet
- Double d : $\frac{1}{4}$ the field

$$g = GM / d^2$$

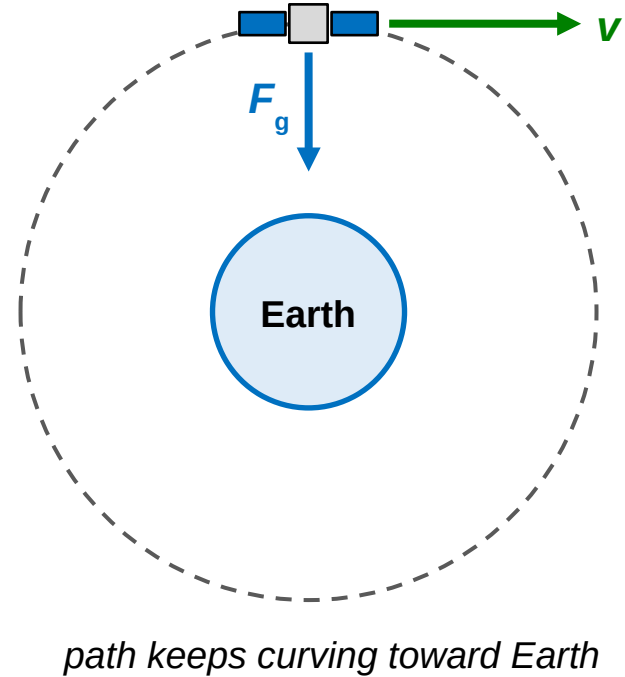
Earth's surface (1 R): **9.8 N/kg**

2 R from center: **2.5 N/kg**

Moon's distance (60 R): **0.0027 N/kg**

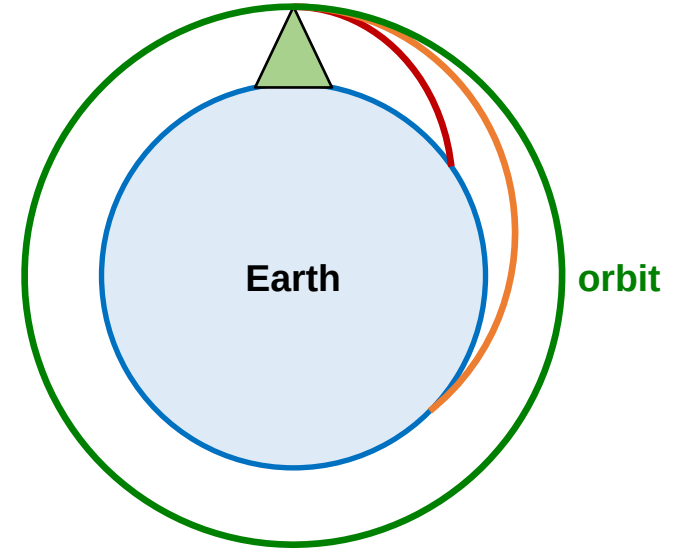
Gravity Bends the Path

- Gravity pulls toward the center
- Velocity points sideways
- Gravity is the centripetal force



Always Falling

- Orbiting objects are always falling
- They move sideways fast enough
- Earth curves away below them



faster launch → lands farther → orbit

Orbital Speed

- Set F_g equal to F_c
- Satellite's mass cancels out
- Closer orbit: faster speed

$$F_g = F_c$$



$$GMm/d^2 = mv^2/d$$

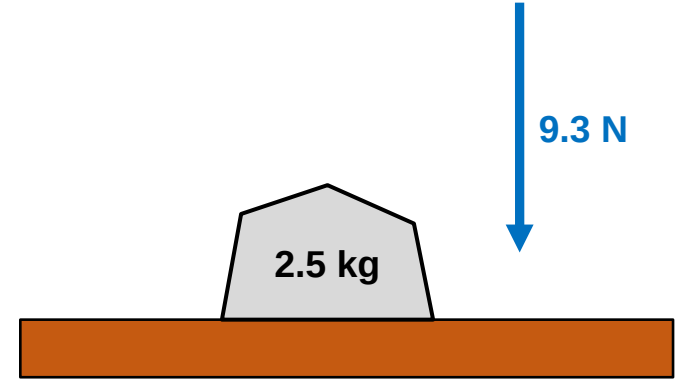


$$v = \sqrt{GM/d}$$

$M = \text{planet's mass, } d = \text{orbit radius}$

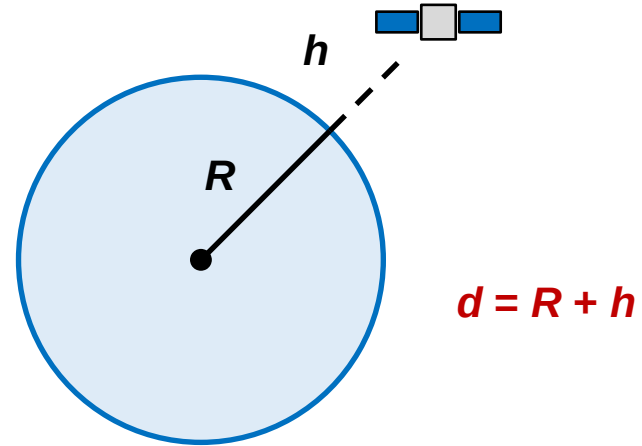
Example: Field Strength on Mars

A rover on Mars picks up a 2.5 kg rock. Mars pulls on the rock with a force of 9.3 N. What is the gravitational field strength on Mars?



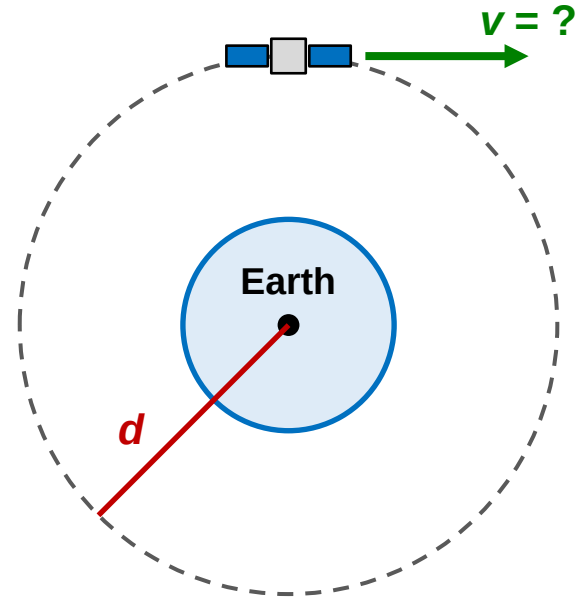
Example: Gravity at the Space Station

The space station orbits 4.2×10^5 m above Earth's surface. Earth's mass is 5.97×10^{24} kg and its radius is 6.37×10^6 m. What is g at the station?



Example: Orbital Speed

The space station orbits 6.79×10^6 m from Earth's center. Earth's mass is 5.97×10^{24} kg. How fast must the station move to stay in orbit?



Big Ideas

- Mass makes a field; lines point toward it
- $g = F/m$ (N/kg), weaker with distance
- Gravity is the centripetal force for orbits
- Orbiting objects are always falling