AM-05.02 — Orbital speed, period and altitude: what changes when you go higher

Essential answer

Orbital speed, period and altitude: what changes when you go higher. A higher orbit is not simply the same motion farther away. Gravity is weaker, the required circular speed is lower, and the path is longer. The combined result is a slower spacecraft with a longer orbital period. The rest of the course turns that idea into an auditable line of reasoning: explicit units, stated assumptions, reproducible calculations, order-of-magnitude checks and interpretation limits. A result is useful only when the reader can explain what it measures, where every input came from and which engineering decision it can support.

Reasoning map

1. 1 — Build a mental picture before using a formula
2. 2 — Essential vocabulary before going further
3. 3 — Understand the mechanism step by step
4. 4 — The formula, only now
5. 5 — What the units tell you

A higher orbit is not simply the same motion farther away. Gravity is weaker, the required circular speed is lower, and the path is longer. The combined result is a slower spacecraft with a longer orbital period.

orbital speed — distance traveled along the orbit per unit time.

Before calculating

Quantity:	AM-05.02 — Orbital speed, period and altitude: what changes when you go higher
Check:	units + order of magnitude + assumptions
Decision:	state what the result actually supports

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2 — Essential vocabulary before going further

orbital speed — distance traveled along the orbit per unit time.

orbital period — time for one complete revolution.

altitude — height above a reference surface.

orbital radius — distance from the centre of the body.

second — SI unit of time.

3 — Understand the mechanism step by step

For a simplified spherical planet, orbital radius equals planetary radius plus altitude. A 400 km altitude Earth orbit therefore has a radius near 6,778 km.

Circular speed falls as orbital radius grows. This is a property of the required equilibrium; changing from one orbit to another still requires a maneuver.

The path is larger while the orbital speed is lower, so a revolution takes more time.

4 — The formula, only now

How to read it: T is the period; π, pronounced 'pi', is about 3.1416; r^3 means r multiplied by itself three times; μ is the gravitational parameter.

Active reading

Sections:	2 — Essential vocabulary before going further ; 3 — Understand the mechanism step by step
Verification:	A value is usable only with its unit and calculation boundary.
Exercise:	change one assumption and predict the direction of change before recalculating

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For r ≈ 6,778 km around Earth, evaluate r^3/μ, take the square root, then multiply by 2π. The result is about 5,545 s; dividing by 60 gives about 92.4 min.

5 — What the units tell you

6 — Three concrete demonstrations

r = 6,800 km gives about 93.0 min; r = 7,000 km gives about 97.1 min.

7 — Why this matters for a Mars mission

Periods matter for rendezvous, ground coverage, communication passes and the timing of science observations.

8 — Common traps and misleading intuitions

comparing different planets by altitude alone.

9 — What I should be able to explain at the end

explain the idea in ordinary words

read and pronounce the important symbols

repeat at least one calculation without hidden steps

Active reading

Sections:	5 — What the units tell you ; 6 — Three concrete demonstrations
Verification:	A value is usable only with its unit and calculation boundary.
Exercise:	change one assumption and predict the direction of change before recalculating

identify what the simplified model assumes and does not prove

Connecting altitude, speed and period without misleading intuition

Moving to a higher circular orbit produces a counterintuitive pair of changes: orbital speed decreases while orbital period increases. Gravity is weaker and the circumference to travel is larger. The relations $v = \sqrt{(\mu/r)}$ and $T = 2\pi\sqrt{(r^3/\mu)}$ describe the same dynamical balance through different observables.

A prograde burn from a circular orbit does not instantly create a higher circular orbit. It raises the opposite side first and produces an ellipse. If a new circular orbit is required, a second burn is needed near the new altitude. That is why altitude, speed and energy must be discussed together.

Mission consequences include revisit rate, eclipses, communication geometry, radiation exposure and rendezvous opportunities. Period is therefore not just a textbook number; it becomes part of the spacecraft timeline and power budget.

10 — Guided exercises and answers

11 — NASA / JPL sources for further study

NASA Science — Basics of Space Flight, Gravity & Mechanics

Active reading

Sections:	Connecting altitude, speed and period without misleading intuition ; 10 — Guided exercises and answers
Verification:	NASA Science — Basics of Space Flight, Gravity & Mechanics
Exercise:	change one assumption and predict the direction of change before recalculating