AM-05.07 — Rendezvous and orbital phasing: meeting an object that is already moving

Essential answer

Rendezvous and orbital phasing: meeting an object that is already moving. Orbital rendezvous is not a car chase. Both vehicles are falling around a planet, so changing speed changes the orbit itself. A successful rendezvous requires matching both position and velocity. 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

Orbital rendezvous is not a car chase. Both vehicles are falling around a planet, so changing speed changes the orbit itself. A successful rendezvous requires matching both position and velocity.

rendezvous — same orbital location at the same time with compatible velocity.

Before calculating

Quantity:	AM-05.07 — Rendezvous and orbital phasing: meeting an object that is already moving
Check:	units + order of magnitude + assumptions
Decision:	state what the result actually supports

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2 — Essential vocabulary before going further

rendezvous — same orbital location at the same time with compatible velocity.

phasing — adjusting timing/angle between vehicles.

phasing orbit — temporary orbit with a different period.

relative velocity — one vehicle’s velocity as seen from the other.

proximity operations — controlled final approach.

3 — Understand the mechanism step by step

Crossing the same point at high relative speed is not a rendezvous.

A chaser may lower its orbit to shorten its period and catch a target ahead, then raise orbit again.

Phasing, transfer, approach, station-keeping and docking are distinct stages with progressively tighter control.

4 — The formula, only now

How to read it: Read 'delta tee': difference between the target period and phasing-orbit period.

97.1 − 93.0 = 4.1 min per revolution; five revolutions give roughly 20.5 min of accumulated timing difference.

5 — What the units tell you

6 — Three concrete demonstrations

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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r=6,800 km gives ≈93.0 min while r=7,000 km gives ≈97.1 min around Earth.

A 4.1 min difference per revolution accumulates to about 20.5 min after five phasing revolutions.

Near a target, relative velocity—not orbital speed alone—becomes the critical quantity.

7 — Why this matters for a Mars mission

Rendezvous logic underlies assembly, refueling, depots and multi-vehicle Mars architectures.

8 — Common traps and misleading intuitions

aiming at the target’s current location.

matching distance but not velocity.

forgetting burns change the orbit.

treating final approach as a straight-line interception.

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

identify what the simplified model assumes and does not prove

Orbital rendezvous is a timing problem as much as a velocity problem

Active reading

Sections:	7 — Why this matters for a Mars mission ; 8 — Common traps and misleading intuitions
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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A chaser cannot aim at the target’s current position because the target continues to move. Phasing temporarily changes orbital period so the relative angle evolves by the required amount before the chaser returns to a compatible orbit.

A lower orbit usually has a shorter period, so the chaser gains phase on a higher target. Reaching that lower orbit first requires a retrograde burn—one of the classic orbital counterintuitions where slowing locally can lead to faster angular progress after descending.

Final approach switches from broad period reasoning to relative navigation: range, closing rate, line of sight, corridors and hold points. Success means reducing both position and relative velocity, not merely reaching the same location quickly.

10 — Guided exercises and answers

11 — NASA / JPL sources for further study

NASA Science — Basics of Space Flight, Gravity & Mechanics

NASA Science — Basics of Space Flight, Navigation

Active reading

Sections:	10 — Guided exercises and answers ; 11 — NASA / JPL sources for further study
Verification:	NASA Science — Basics of Space Flight, Gravity & Mechanics | NASA Science — Basics of Space Flight, Navigation
Exercise:	change one assumption and predict the direction of change before recalculating