AM-05.06 — Hohmann transfer: moving between circular orbits with two burns

Essential answer

Hohmann transfer: moving between circular orbits with two burns. A Hohmann transfer uses an ellipse tangent to two coplanar circular orbits and two burns. It is not always the optimum real-world solution, but it is one of the clearest models for learning orbital transfers. 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 Hohmann transfer uses an ellipse tangent to two coplanar circular orbits and two burns. It is not always the optimum real-world solution, but it is one of the clearest models for learning orbital transfers.

initial orbit — starting circular orbit.

Before calculating

Quantity:	AM-05.06 — Hohmann transfer: moving between circular orbits with two burns
Check:	units + order of magnitude + assumptions
Decision:	state what the result actually supports

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2 — Essential vocabulary before going further

initial orbit — starting circular orbit.

final orbit — target circular orbit.

transfer ellipse — ellipse tangent to both circular orbits.

first burn — maneuver that enters the transfer ellipse.

circularization — second burn matching the final circular speed.

3 — Understand the mechanism step by step

A prograde burn from the lower orbit raises the far side of the new ellipse.

The engine is off in the impulsive model while gravity carries the spacecraft along the ellipse.

At apoapsis, a second prograde burn matches the target circular speed.

4 — The formula, only now

How to read it: r_1 is starting radius, r_2 target radius, μ gravitational parameter; brackets group operations.

For r_1=7,000 km, r_2=14,000 km and Earth $\mu \approx 398{,}600$ km³/s², initial circular speed is ≈7.546 km/s and the bracket factor ≈0.1547, giving $\Delta v_1 \approx 1.17$ km/s.

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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5 — What the units tell you

6 — Three concrete demonstrations

The ideal two-body burns are about 1.17 km/s and 0.98 km/s, total roughly 2.15 km/s.

Without circularization the spacecraft simply falls back along the transfer ellipse.

Reverse the logic using retrograde burns.

7 — Why this matters for a Mars mission

The model provides the conceptual backbone for later Earth–Mars transfer calculations.

8 — Common traps and misleading intuitions

treating real interplanetary missions as exact Hohmann copies.

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

explain the idea in ordinary words

read and pronounce the important symbols

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

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repeat at least one calculation without hidden steps

identify what the simplified model assumes and does not prove

What a Hohmann transfer teaches—and simplifies

A Hohmann transfer links two circular coplanar orbits through an ellipse tangent to both. The first impulse enters the transfer ellipse; the second circularizes at the destination. It is optimal only under a particular ideal model and does not mean every real mission uses exactly two instantaneous burns.

The calculation separates three different speeds: circular departure speed, transfer-ellipse speed after the first burn, and target circular speed. The burn costs are differences between the appropriate local speeds, not simply the difference between two circular speeds.

For Earth–Mars work the Hohmann model is mainly an order-of-magnitude tool. Real planets are not perfect coplanar circles, and mission design uses ephemerides, launch dates, arrival geometry and launcher constraints.

10 — Guided exercises and answers

11 — NASA / JPL sources for further study

NASA Science — Basics of Space Flight, Trajectories

Active reading

Sections:	What a Hohmann transfer teaches—and simplifies ; 10 — Guided exercises and answers
Verification:	NASA Science — Basics of Space Flight, Trajectories
Exercise:	change one assumption and predict the direction of change before recalculating