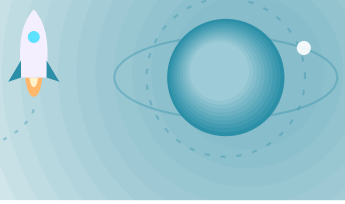
TEACHER ANSWER KEY

Tier 5 · Transfers & Rendezvous



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Predictions below have fixed answers. Questions marked **Measured live** are graded against what the simulation actually produces, so the exact value depends on the student's run; use the tolerance shown in-game.

T5-01 · Two-Burn Mail (High School (9–12))

P1. Going from a low circle to a higher circle takes two burns: one now and one later. Which pair of pushes describes them (first burn, then second burn)?

Answer: Measured live in the sim: compare the student's answer with the result shown after the flight (tolerance applies).

P2. After the first burn you coast up an oval orbit. How many MORE burns does the trip need to end as a circle at the top?

Answer: One more, at the top of the oval

Standards: HS-ESS1-4 (practice) – Plan a two-burn transfer between circular orbits with pinned r1, r2 and mu. Hohmann minimality is qualified to its assumed transfer family. Teacher note: the craft starts in a circle 100 km up and must end in a circle 200 km up (semi-major axis within 2%, eccentricity at most 0.02), arriving within 2% of the analytic 18.1-minute trip and using at most 105% of the ideal 144.9 m/s. Transfer: different radii and an inward transfer.

T5-02 · Meet the Moving Mailbox (High School (9–12))

P1. If you burn right now, where will the mailbox be, compared with you, when you reach the top of your transfer?

Answer: Measured live in the sim: compare the student's answer with the result shown after the flight (tolerance applies).

P2. How many minutes will it take to coast from the burn up to the top of the oval? Mark the range you expect.

Answer: Measured live in the sim: compare the student's answer with the result shown after the flight (tolerance applies).

Phase angles are engineering enrichment; collision or capture is never inferred from path crossing. Teacher note: the craft circles 100 km up and the mailbox 200 km up, 16.6° ahead (the exact lead for a two-burn transfer); the gate is 5 km at the top of the transfer. Transfer: a new target mean motion. No standard code is claimed.

T5-03 · Fall Back to Catch Up (High School (9–12))

P1. Right after you push against your motion (a retrograde burn), is your speed faster or slower than before?

Answer: Slower

P2. Over the next laps, do you end up ahead of, or behind, the place you would have been if you had not pushed?

Answer: Ahead of

HS orbital computational modelling; no standard code is claimed. Teacher note: the Modular Orbital Tug circles 100 km up with the satellite 15° (183 km) ahead; a 15.9 m/s push against its motion makes an orbit with a 1,917-second lap, and after two laps it has caught up. A catch-up zone of 15 km forgives a burn that is 1 m/s off; the RCS fuel budget is 2.5 times the ideal. Transfer: start leading rather than trailing.

T5-04 · Change the Plane (High School (9–12))

P1. Where should the plane-change burn happen?
Answer: At a node, where the two orbits cross

P2. Which point makes the same plane change cheaper?
Answer: The slow point

Combined plane and altitude change is an extension. deltaV = 2 v sin(deltaI / 2) applies only to a pure equal-speed plane change. Teacher note: the craft circles 100 km up and the target orbit is tilted 5°; the orbit must end within 1° of it using at most 110% of the 196 m/s a pure plane change costs. Transfer: a different tilt. No standard code is claimed.

T5-05 · Satellite Rescue and Dock (Grades 6–12)

P1. Which way does the satellite's docking port face, compared with the way you are approaching?
Answer: Measured live in the sim: compare the student's answer with the result shown after the flight (tolerance applies).

P2. How fast can the two ports be closing and still latch?
Answer: Measured live in the sim: compare the student's answer with the result shown after the flight (tolerance applies).

Standards: HS-PS2-2 (practice) – The 1D capture subtask supports momentum conservation in a closed two-body capture.; MS-PS2-1 (practice) – The 1D capture subtask supports the collision/capture idea at low closing speed.
Full 3D docking is enrichment. Teacher note: the satellite is a second Modular Orbital Tug 120 m ahead, nose pointing back, so the ports face each other; the latch needs the ports closer than 1.25 m, closing at no more than 0.75 m/s and lined up within 18.2°, then the craft stay joined for 10 s. The RCS budget is 20 times the ideal fuel. Using AUTO DOCK is recorded as an assist and leaves the attempt unscored. Transfer: an unfamiliar port orientation and target mass. Efficiency is judged only after capture.
