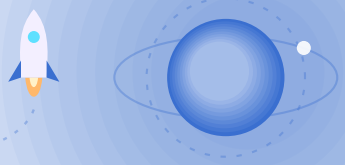
TEACHER ANSWER KEY

Tier 4 · Falling Around the World



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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.

T4-01 · Miss the Ground (Grades 6–12)

P1. At this height a craft can hit the ground, circle the world, or escape into space, depending on its sideways speed. Which list puts the three results in order from the SLOWEST speed to the FASTEST?

Answer: Hits the ground, circles the world, escapes into space

Standards: MS-ESS1-2 (practice) – Qualitative core: gravity and sideways speed make an object keep falling around the body.; HS-ESS1-4 (enrichment) – Quantitative extension: relate launch speed to bound and unbound orbits.
Teacher note: the craft starts in a circular orbit 100 km up, above the air, so nothing slows it down; the safe radius is the top of the air. Time warp is allowed and the engine is not needed. Transfer: a different mu and radius.

T4-02 · Circularize or Burn (High School (9–12))

P1. Our orbit is an oval. To turn it into a circle as high as its highest point, where on the orbit should the engine burn?

Answer: At apoapsis (the high point)

Standards: HS-ESS1-4 (practice) – Use the orbit diagnostics to circularize and check the result against a target ring.
Teacher note: the craft starts at the high point of a 100 km by 200 km oval orbit, nose along its path; the circularizing burn there is a prograde burn of about 71 m/s. Both ends must end within 3% of 200 km (eccentricity at most 0.03) and the speed change must be 0.9 to 1.1 times the circularizing burn. Transfer: a different orbit height and engine thrust.

T4-03 · Equal-Area Courier (Grades 6–12)

P1. How many times faster is the craft at the lowest point of its oval orbit than at the highest point? 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).

P2. Where on its oval orbit does the craft move fastest?

Answer: At its lowest point (closest to Terra)

P3. Draw a line from Terra to the craft. In equal amounts of time, what does the line sweep out?

Answer: The same area everywhere

Standards: HS-ESS1-4 (practice) – Predict orbital speed from equal-time swept areas; sector areas agree within 2% in the validated ideal model.
The MS version is qualitative speed and position only. Teacher note: the craft flies a 100 km by 700 km oval orbit; the speed ratio between the low and the high point equals the ratio of their distances from the centre (angular momentum), graded within 10%. The equal-time slices are one eighth of the period. Transfer: a different eccentricity.

T4-04 · Periapsis Energy Bonus (High School (9–12))

P1. We will fire the engine for the same speed change twice: once at the low point of the orbit and once at the high point. Which burn gives the craft more energy?

Answer: At the low point (high speed)

P2. How many times more energy does the same burn add at the low point than at the high point? 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).

Oberth enrichment; the engine does not become more efficient. Teacher note: the craft flies a 100 km by 700 km oval orbit; the learner burns about 40 m/s prograde at the low point and again at the high point, and the energy gain of the last burn must agree with v dv + dv^2/2 within 1%. Transfer: a different burn direction. No standard code is claimed.

T4-05 · Gravity Still Works Here (Grades 6–12)

P1. Is there gravity at orbital height?

Answer: Yes, gravity still acts and supplies the orbit's centripetal force

P2. In free fall, what does a push meter (an accelerometer, which feels pushes like the seat under you) read?

Answer: About zero

P3. Predict the pull of gravity at the new orbital radius. 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).

Standards: HS-PS2-4 (practice) – Gravitational portion: inverse-square predictions within the model/source tolerance.
MS: qualitative gravity model only. Teacher note: the craft starts in a circular orbit 100 km up; the check reads the live gravity and the push the craft feels (proper acceleration, about zero in free fall); the slider is graded on its centre, within 10% of mu / r^2 at 1.5 times the orbit radius. Transfer: a new body.
