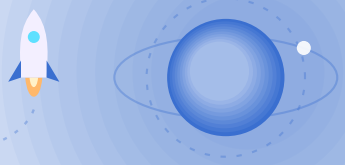
LESSON T4-04 · TIER 4 · FALLING AROUND THE WORLD

# Periapsis Energy Bonus

HIGH SCHOOL (9–12)



Name _____ Date _____ Class / Period _____

## Burn low, gain more

The same engine burn changes your speed by the same amount anywhere, but it does not change your energy by the same amount. Energy of motion depends on speed squared, so a burn when you are already fast adds the most. That is the Oberth effect.

**Mission goal: burn about {dvNominal} m/s at the low point and again at the high point of the oval orbit, and compare the energy each burn adds.**

## 1 LOOK

OBSERVE BEFORE YOU TOUCH A CONTROL

### Step 1 · Burn at the low point

- Our orbit is _____ km by _____ km. The craft moves at _____ m/s at its low point and _____ m/s at its high point.
- Gain per kilogram = v × dv + dv² ÷ 2, where v is the speed when the burn starts and dv the speed it adds.

### Step 2 · Burn at the high point

- A burn of _____ m/s at the low point adds about _____ kJ for every kilogram.
- Now do the same burn at the high point, where the craft is slow, and compare.

**Write the numbers shown in the sim in the blanks above, then record what you notice:**

## 2 PREDICT

COMMIT TO A HYPOTHESIS FIRST

**Prediction 1.** 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?

*Hint: Energy of motion grows with speed squared. A craft that is already moving fast gains more energy from the same extra speed.*

□ At the high point (low speed)

□ At the low point (high speed)

□ Both give the same

**Because...**

**Prediction 2.** How many times more energy does the same burn add at the low point than at the high point? Mark the range you expect.

*Hint: The gain per kilogram is $v \times dv + dv^2 \div 2$, where $v$ is the speed when the burn starts and $dv$ the speed it adds.*

My prediction (circle or fill in): _____ to _____

**Because...**

## 3 EXPERIMENT

CHANGE ONE VARIABLE AT A TIME

**Step 1.** Click PROGRADE in the Flight Computer so the nose follows the way you are moving. Press **[.]** to speed up time until the Height stops falling and starts to rise: that is the low point. Slow time down with **[,]**. Then press **[Space]**, hold **[Z]** for about 3 seconds, and press **[X]** to cut the engine.

**Step 2.** Press **[.]** to speed up time until the Height stops rising: that is the high point. Slow time down with **[,]**. Then press **[Space]**, hold **[Z]** for about 3 seconds, and press **[X]** to cut the engine.

| Trial | What I changed | What I measured / saw | Matched my prediction? |
|---|---|---|---|
| 1 | | | Yes · No · Partly |
| 2 | | | Yes · No · Partly |
| 3 | | | Yes · No · Partly |

## 4 EXPLAIN

CLAIM · EVIDENCE · REASONING

**Claim** — What did you find out? (answer the mission goal in one sentence)

**Evidence** — Which numbers or observations from the sim support your claim?

**Reasoning** — Which science idea connects your evidence to your claim?

**Self-check:** □ I made a prediction before experimenting □ I used numbers from the sim □ I explained *why*, not just *what*