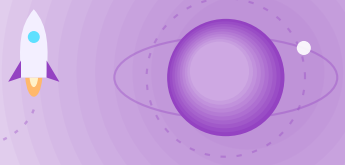
LESSON T2-05 · TIER 2 · PROPELLANT & STAGING

Payload Frontier / SSTO

HIGH SCHOOL (9–12)



Name _____ Date _____ Class / Period _____

The payload frontier

To reach orbit, a rocket must be mostly fuel. Every kilogram of tank, engine and cargo makes it harder. Rockets that drop their empty stages carry less dead weight, so they get there with more cargo.

Mission goal: fly the two-stage Orbital Starter, with its capsule, into an orbit {orbitKm} kilometres up.

1 LOOK

OBSERVE BEFORE YOU TOUCH A CONTROL

Step 1 · Climb with two stages

- To circle the world at _____ kilometres a rocket needs about _____ m/s of speed change, with nothing lost to air or steering.
- Our Orbital Starter weighs at most _____ kg and must deliver at least its capsule and last stage.

Step 2 · Go sideways to stay up

- The Sounding Rocket weighs _____ kg. Besides its fuel it carries a tank, fins, a parachute, an engine and a probe.
- Our Orbital Starter has _____ m/s of ideal speed gain even if it kept all its stages.

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. The Science Sounding Rocket has one stage. Could it reach orbit all by itself?

Hint: An orbit needs a lot of sideways speed. The rocket equation says how much speed a rocket's fuel can give it.

□ Yes, one stage can reach orbit

□ No, one stage falls short of orbit

Because...

Prediction 2. What is the biggest thing holding that one-stage rocket back?

Hint: The fuel is only a part of a rocket's weight. The rest is tanks, engine and cargo that all have to be lifted.

□ Too much weight in the engine

□ Too little of its weight is fuel

□ Too much weight in the payload

□ Too much weight in tanks, fins and frame

Because...

3 EXPERIMENT

CHANGE ONE VARIABLE AT A TIME

Step 1. Press **[Space]** to light the first engine and **[Z]** for full throttle. Climb straight up. When the tank runs dry, press **[Space]** to drop the empty stage and again to light the second engine. Climb past 40 kilometres.

Step 2. Hold **[W]** a moment to lean the rocket over toward the horizon so it builds sideways speed. (**[S]** leans it the other way.) Press **[Space]** when a stage runs out. Keep going until the lowest point of your orbit is above 56 kilometres, then press **[X]**.

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*