

Rocket Equation Simulator

Classroom worksheet · Interactive simulation: <https://lkforge.com/tools/physics/rocket/>

Name: _____ Date: _____

Learning objectives

- Apply the Tsiolkovsky rocket equation.
- Relate delta-v to mass ratio and exhaust velocity.
- Explain why staging helps.

Variables to change

- Exhaust velocity / specific impulse
- Propellant mass
- Payload mass

Procedure

1. Set a mass ratio and exhaust velocity and read the achievable delta-v.
2. Increase the propellant fraction and observe delta-v rise.
3. Increase exhaust velocity and observe the effect.

Observations

Record delta-v as you vary the mass ratio and exhaust velocity.

Questions

1. Write the Tsiolkovsky rocket equation.
2. Why is the relationship logarithmic in mass ratio?
3. What is specific impulse?

4. Why do rockets use multiple stages?

5. How do you increase delta- v ?

Answer key (instructors)

- **1.** $\Delta v = v_e \cdot \ln(m_o/m_f) = I_{sp} \cdot g \cdot \ln(m_o/m_f)$.
- **2.** As propellant burns, the remaining rocket also has to be accelerated, giving diminishing returns.
- **3.** A measure of exhaust efficiency — effectively exhaust velocity divided by g ; higher I_{sp} gives more Δv per propellant.
- **4.** Dropping empty tanks reduces the mass that must be accelerated, boosting the overall Δv .
- **5.** Increase exhaust velocity (I_{sp}) or the propellant-to-total mass ratio.

The Tsiolkovsky equation $\Delta v = v_e \cdot \ln(m_o/m_f)$ ties a rocket's velocity change to its exhaust velocity and mass ratio. The logarithm means propellant gives diminishing returns, so high specific impulse and staging (shedding dead mass) are key to reaching orbit.