QUIZ CUBES

Class 11/12 | AP Physics | IIT JEE | NEET

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Tsiolkovsky's Rocket Equation

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Q1. A rocket in deep space is initially at rest. It expels gas with a constant velocity u relative to the rocket. According to the rocket equation, what happens to the rocket's velocity as it expels gas?

A. It remains constant.
B. It increases linearly over time.
C. It increases logarithmically.
D. It decreases.

Q2. If a rocket of mass m expels gas at a constant rate, how does the mass of the rocket change over time?

A. It remains constant.
B. It increases linearly.
C. It decreases exponentially.
D. It decreases linearly.

Q3. The Tsiolkovsky rocket equation is given by $\Delta v = u \ln(m_i / m_f)$, where Δv is the change in velocity, v_e is the exhaust velocity, m_i is the initial mass, and m_f is the final mass. What does this equation imply about the relationship between Δv and m_f?

A. Δv increases as m_f increases.
B. Δv decreases as mf increases.
C. Δv is independent of m_f.
D. Δv is directly proportional to m_f.

Q4. A rocket expels 20% of its initial mass as fuel. If the exhaust velocity v_e is constant, what happens to the rocket's final velocity v_f, compared to a rocket expelling 40% of its initial mass?

A. v_f will be higher.
B. v_f will be lower.

C. v_f will be the same.
D. v_f will be twice as much.

Q5. During the launch of a rocket, the exhaust gases are expelled at a velocity v_e. If the initial mass of the rocket is m_i and the final mass is mf, which of the following best describes the total change in velocity Δv?

A. $\Delta v = v_e (m_i - m_f)$
B. $\Delta v = v_e \ln(m_i / m_f)$
C. $\Delta v = (m_i - m_f) / v_e$
D. $\Delta v = \ln(v_e / m_f)$

Q6. A rocket in space is accelerating with a constant thrust. As the rocket expels fuel and its mass decreases, what happens to its acceleration?

A. Acceleration remains constant.
B. Acceleration decreases.
C. Acceleration increases.
D. Acceleration becomes zero

Q7. If a spacecraft wants to double its change in velocity by expelling the same propellant mass but with double the exhaust velocity v_e, which of the following is true?

A. The final velocity will remain the same.
B. The final velocity will double.
C. The final velocity will quadruple.
D. The final velocity will increase by a factor of √2.

Q8. A rocket moving in space expels gas at a velocity of 2000 m/s. If the initial mass of the rocket is 5000 kg and the final mass is 3000 kg, what is the change in velocity Δv of the rocket?

A. 2000 m/s
B. 1000 m/s
C. 1220 m/s
D. 2800 m/s

Q9. In a real-life scenario, a rocket experiences drag and gravity. How do these factors affect the application of the ideal rocket equation?

A. They have no effect.
B. They increase the effective exhaust velocity.
C. They decrease the effective change in velocity.
D. They cause the rocket to accelerate faster.

Q10. When considering multi-stage rockets, which of the following is an advantage of staging?

A. It increases the mass of the rocket.
B. It allows the rocket to discard empty fuel tanks, reducing mass.
C. It decreases the thrust produced.
D. It simplifies the design of the rocket.

Answers Uncubed

Q1. Answer: C. It increases logarithmically.
Explanation: The rocket's velocity increases logarithmically as it expels gas due to the exponential relationship between the change in mass and the change in velocity described by the rocket equation.

Q2. Answer: D. It decreases linearly.
Explanation: As the rocket expels gas at a constant rate, its mass decreases linearly over time, which affects the overall thrust and velocity according to the rocket equation.

Q3. Answer: B. Δv decreases as mf increases.
Explanation: According to the Tsiolkovsky rocket equation, as the final mass mf increases, the ratio m_i / mf decreases, leading to a smaller logarithmic value and thus a smaller Δv.

Q4. Answer: B. v_f will be lower.
Explanation: Expelling more fuel mass (40%) results in a greater change in velocity compared to expelling less fuel mass (20%), assuming the exhaust velocity remains constant.

Q5. Answer: B. $\Delta v = v_e \ln(m_i / m_f)$
Explanation: This is the Tsiolkovsky rocket equation, which shows the change in velocity as a function of the exhaust velocity and the natural logarithm of the initial and final masses.

Q6. Answer: C. Acceleration increases.
Explanation: As the rocket expels fuel, its mass decreases. According to Newton's second law (F = ma), if the thrust (force) remains constant but the mass decreases, the acceleration must increase. This is because the same amount of force is now acting on a smaller mass, resulting in a greater acceleration.

Q7. Answer: B. The final velocity will double.
Explanation: Doubling the exhaust velocity while keeping the same propellant mass effectively doubles the change in velocity Δv according to the rocket equation $\Delta v = v_e \ln(m_i / m_f)$

Q8. Answer: C. 1220 m/s
Explanation: Using the rocket equation $\Delta v = v_e \ln(m_i / m_f)$, we get $\Delta v = 2000 \ln(5000 / 3000) \approx 1220$ m/s.

Q9. Answer: C. They decrease the effective change in velocity.
Explanation: Drag and gravity reduce the effective change in velocity that can be achieved by the rocket because additional energy is needed to overcome these forces.

Q10. Answer: B. It allows the rocket to discard empty fuel tanks, reducing mass.
Explanation: Staging enables rockets to shed the mass of empty fuel tanks, which increases efficiency and allows the remaining stages to achieve greater velocity. Mathematically also, when mf reduces the RHS increases that is greater change in velocity. $\Delta v = v_e \ln(m_i / m_f)$