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SPACE TECH SERIES

Katherine Johnson

The Orbital Mechanics Pioneer

Precision Under Pressure: Katherine Johnson and the Mathematics of Spaceflight

Katherine Johnson (1918-2020) was one of the most influential mathematicians of the American space program. A child prodigy who finished high school at 14 and college at 18, she joined the National Advisory Committee for Aeronautics (NACA), the agency that became NASA, in 1953, working in a segregated computing unit of Black women mathematicians known as the West Area Computers.

Johnson specialized in orbital mechanics, the branch of physics governing how objects move under gravity in space. She co-authored a foundational 1960 report on calculating the trajectory of a spacecraft's launch and reentry, becoming one of the first women at her center to receive author credit on such work.

Her calculations underpinned Alan Shepard's suborbital flight in 1961 and, most famously, John Glenn's orbital mission aboard Friendship 7 in 1962. When NASA transitioned to electronic IBM computers, Glenn insisted that Johnson personally verify the computer's trajectory calculations by hand before he would fly, a striking testament to the trust her precision commanded.

Over her career Johnson contributed to the Apollo program, including the 1969 Moon landing and the trajectory analysis that helped return the crippled Apollo 13 crew safely, as well as early Space Shuttle work. She published or co-published 26 scientific papers.

In 2015 President Barack Obama awarded her the Presidential Medal of Freedom. The 2016 book and film "Hidden Figures" brought her story to a global audience. Katherine Johnson died in 2020 at age 101, celebrated as a symbol of both mathematical excellence and the fight for equality in science.

Part 1 · Comprehension & Analysis

1. How does the passage use specific evidence to support the claim that Johnson's precision earned exceptional trust?

2. What is orbital mechanics, and why was expertise in it essential to human spaceflight?

3. Why was Johnson's authorship credit on the 1960 trajectory report historically significant?

4. Beyond Friendship 7, identify two later missions or programs to which Johnson contributed and describe her role.

Part 2 · Quantitative Challenge

Reconstructing the Friendship 7 Orbit

Friendship 7 orbited Earth at roughly 28,000 km/h in a nearly circular low-Earth orbit. Using orbital mechanics, reconstruct the orbit. Use GM(Earth) = 3.986 x 10^5 km^3/s^2 and Earth's mean radius = 6,371 km. For a circular orbit, v = sqrt(GM / r) and period T = 2(pi)r / v.

1. Convert the orbital speed of 28,000 km/h to km/s.

2. Using v = sqrt(GM / r), solve for the orbital radius r. (Rearrange to r = GM / v^2.)

3. Find the orbital altitude above Earth's surface. (Subtract Earth's mean radius, 6,371 km.)

4. Calculate the orbital period using T = 2(pi)r / v, and express it in minutes.

Part 3 · Discussion & Extension

Katherine Johnson's hand calculations were used to verify an electronic computer that could work far faster than any human. As we increasingly rely on automated systems and artificial intelligence for high-stakes decisions, when, if ever, should human judgment be required to check the machine? Argue your position using Johnson's example and at least one modern parallel.