The PATH *to the* MOON

The Story of Katherine Johnson

by Joseph Taylor

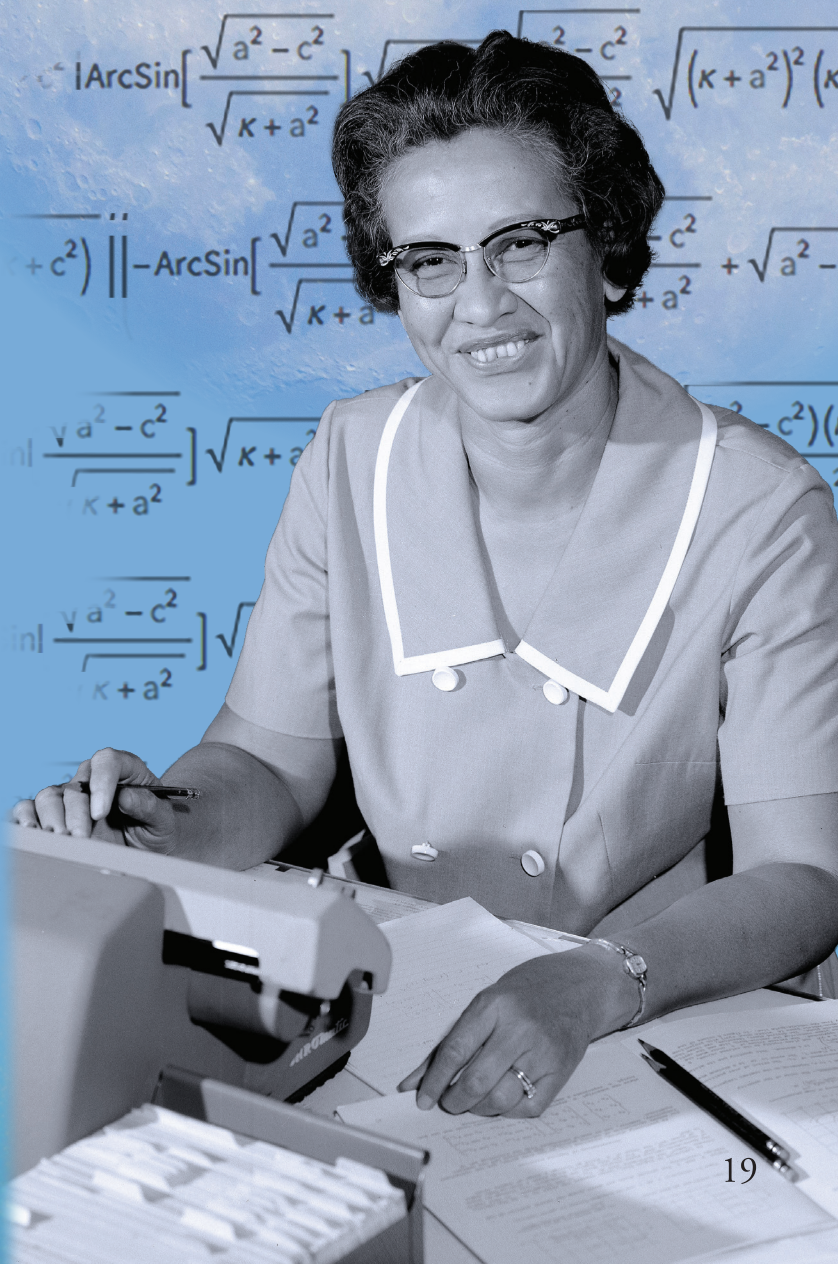
"CAN I GO?" four-year-old Katherine pressed her older brother, Charles, as he headed off to school. "I want to learn."

Charles chuckled and shook his head. But he hadn't said no. So Katherine followed him and her other older siblings, Margaret and Horace, as they strode past dew-covered lawns toward a rising sun. At the entrance to the two-room schoolhouse, Charles turned to his little sister. "Get on home now," he told her. "Learn what you can there. You'll be here soon enough."

Whirling around, Katherine looked down and began counting the steps to the road. She loved numbers and tallied whatever she came across throughout her day: the dishes and silverware she helped wash, the stars she observed in the night sky. Numbers, Katherine discovered, could be found everywhere.

Letters weren't exactly a weakness for her, either. At home, young Katherine was teaching herself how to read. When she entered the first grade the following summer, her new teacher quickly realized how advanced she was. Katherine jumped to second grade. Skipping other elementary grades, she made it all the way to high school at age ten!

Katherine had been born seventy-eight days before the end of World War I, on August 24, 1918, in White Sulphur Springs, West Virginia. She was the youngest child of Joylette and Joshua Coleman. Mrs. Coleman had been a teacher, while Mr. Coleman worked as a farmer, bellman, and janitor. Though her father had only made it through the sixth grade before starting to work full time, Katherine thought he was the smartest man she knew. Time and again, his deftness



DEFTNESS MEANS CLEVERNESS AND ABILITY.

Katherine sits at her desk, with a mechanical calculating machine within reach, at the NASA Langley Research Center in 1962.

with numbers awed her. “He could look at a tree,” she later said, “and know how many boards of wood he could get out of it.”

The Colemans wanted their children to have the finest educations they could and encouraged them to apply themselves to their schoolwork. “You’re as good as anybody,” Mr. Coleman told his children, “but no better.” After school, Katherine and her siblings would sit around the kitchen table doing their homework. Little Katherine would often finish hers first, then help her older siblings with theirs. Always wanting to understand the subjects being taught at school, Katherine wasn’t shy about raising her hand in class to ask questions. “There’s no such thing as a dumb question,” she’d say later. “It’s only dumb if you don’t ask it.”

For many African American families like the Colemans, getting a good education at the time wasn’t easy. Jim Crow laws, enforced in the United States from the late nineteenth century until 1965, kept black people and white people as separate as possible in many facets of life, including work and leisure activities, housing, and transportation. Schools were segregated, too, and high schools for African Americans were not common. Most African American children—including those in White Sulphur Springs—found attending high school out of reach.

That wasn’t going to stop Mr. Coleman from making sure his children continued their educations. When the time came, Katherine’s father moved the family near Charleston, West Virginia, to the town of Institute, where an African American high school had been established. As this town was located one hundred and twenty miles from White Sulphur Springs, Mr. Coleman reluctantly bid goodbye to his family during the school year, remaining behind to keep his jobs.

In high school, young Katherine took advanced math classes and developed a passion for the French language. She graduated at age fourteen and entered historically black

AERONAUTICS IS THE SCIENCE OF FLIGHT! WHEEE!

West Virginia State College after turning fifteen. Some of her math professors there, including William Claytor, the third African American to earn a Ph.D. in mathematics, recognized her potential. "You would make a good research mathematician," he told Katherine her sophomore year. "And I am going to prepare you for this career."

Only about one hundred women in the United States at the time worked as professional mathematicians; fewer still were African American. But Professor Claytor followed through on his pledge, going so far as to create two new math courses just for Katherine, including one about analytic geometry, or equations describing shapes and points in space.

After graduating college with highest honors at eighteen, Katherine accepted a job in rural Virginia teaching at a black elementary school, one of the few occupations open to an educated African American woman. Her father encouraged her to apply to graduate school. As it happened, West Virginia University, an all-white institution, found itself under legal pressure to admit black students, or integrate. The university's president invited Katherine and two black male graduates of her college to attend the school as its first black graduate students. But by then Katherine had married, and after a semester of graduate school she returned to start a family in Virginia, where she would again teach school as her children grew.

Following a family wedding in the early 1950s, a relative visiting from Newport News, Virginia, told Katherine that NACA—the National Advisory Committee for Aeronautics—was hiring female African American mathematicians at its nearby Langley research laboratory. Called "human computers," these women completed complex calculations used by NACA's engineers, at the time all male and almost all white, to design engines and aircraft. Enthusiastic about the possibilities NACA offered, Katherine, along with her husband and three daughters, soon moved near Hampton, Virginia, where NACA was located. The following year Katherine was hired by NACA as a human computer.

Although the work performed by these "computers who wore skirts," as the female employees were informally called, was recognized throughout NACA as meticulous and accurate, the women were usually not treated with much respect. It was the male engineers who designed the research and imparted most of the formulas the women used to calculate their columns of figures, which were filled with results of wind tunnel experiments and other test data. Only men could attend high-level NACA meetings and publish research papers under their own names. Black female employees faced additional obstacles, such as having to use separate equipment, restrooms, and lunch tables.

Katherine ignored the "colored bathrooms," as they were called at the time, and used the restroom closest to where she worked—even after one white woman complained. She usually brought her lunch and ate at her desk, which not only saved time and money but allowed her to avoid the segregated lunchroom. Getting into meetings was a taller

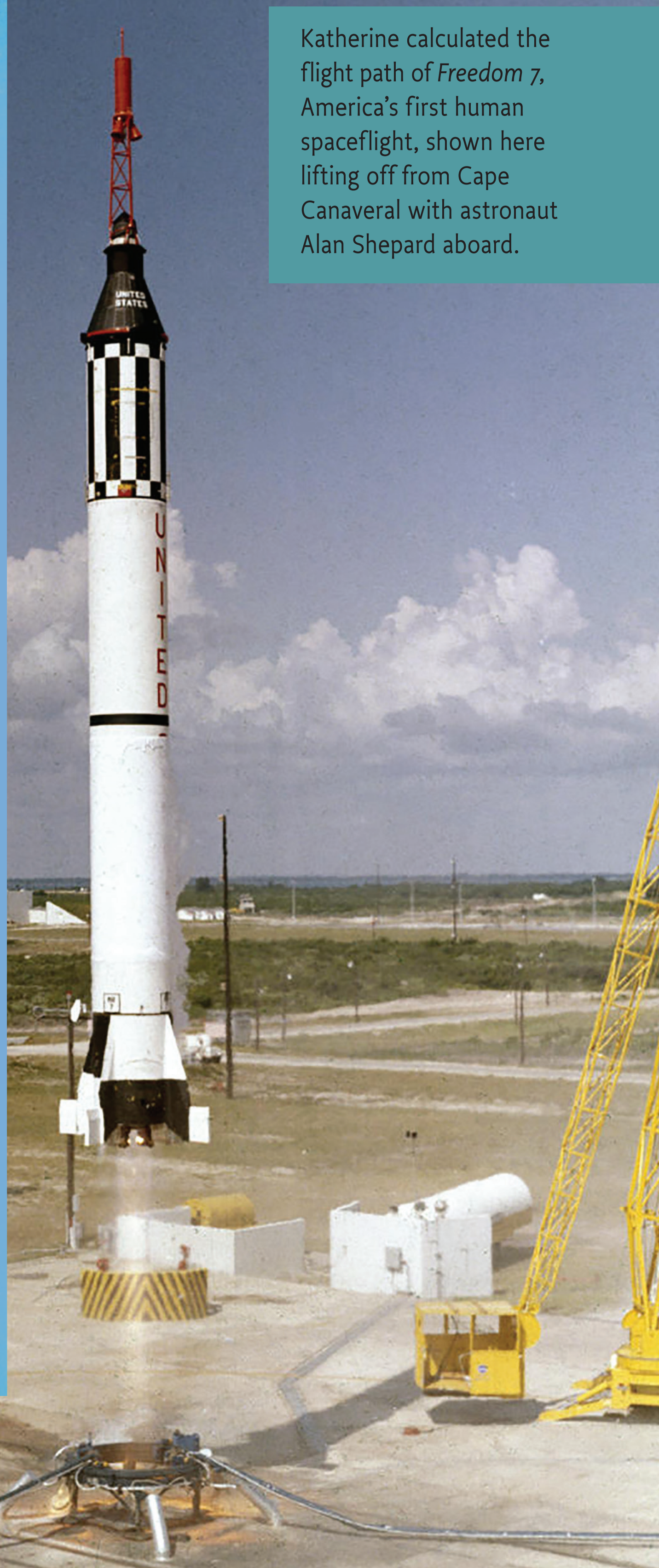
METICULOUS REFERS TO DETAILED WORK DONE WITH PRECISE CARE.

order. Knowing her worth, Katherine kept asking thoughtful questions about the projects underway. Her curiosity and perseverance eventually won her a place at the conference table. She became the first African American woman to attend the engineers meeting and to be promoted to the Space Task Group, formed when NACA became the National Aeronautics and Space Administration, or NASA, in 1958. "I asked questions; I wanted to know why." Katherine recalled. "They got used to me asking questions and being the only woman there."

In 1960, Katherine became the first woman in the Flight Research Division to be credited as an author of a research report. In the paper, she and engineer Ted Skopinski offered the mathematical equations necessary for an orbital spaceflight to land in a predetermined location. Their complex mathematics took into account factors such as Earth's gravity and speed of rotation, and even the fact that Earth is not a perfect sphere but oblate—or slightly squat.

With the birth of NASA, the focus at Langley shifted from developing and testing airplanes to designing rockets and spacecraft. The Soviet Union had stunned the world by placing the first satellite, Sputnik, into Earth orbit on October 4, 1957. It also became the first nation to send a human into outer space when Yuri Gagarin completed an orbit of Earth on April 12, 1961. The "space race" was on, and the United States became intent on matching—and surpassing—Soviet accomplishments.

NASA had already decided that the United States' first human space mission would be a less ambitious suborbital flight—a short flight in which the astronaut would rocket into space but return without orbiting Earth. The flight's



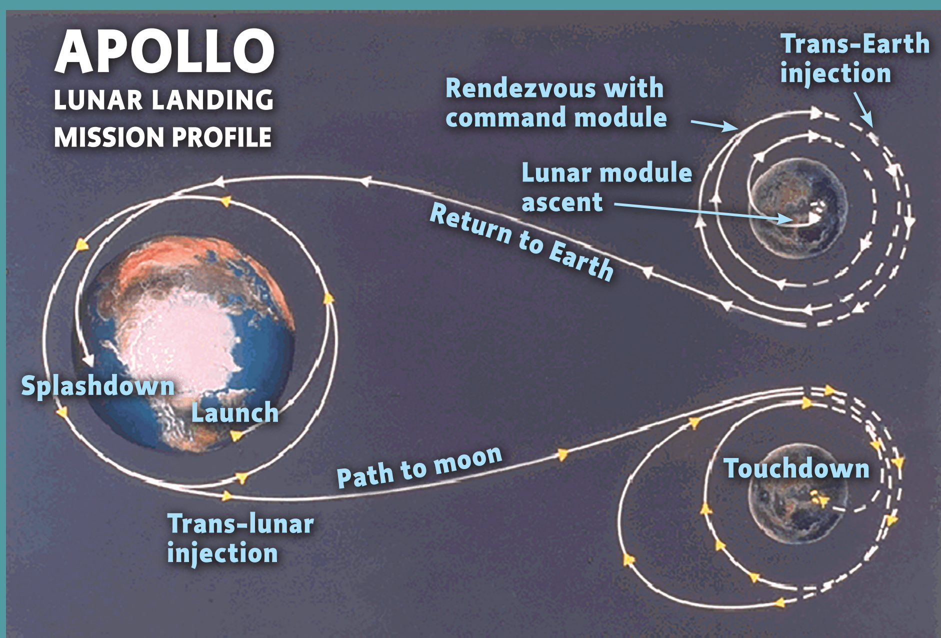
Katherine calculated the flight path of *Freedom 7,* America's first human spaceflight, shown here lifting off from Cape Canaveral with astronaut Alan Shepard aboard.

trajectory would be a parabola, a geometric shape resembling an arch, and would need to be precise, as the lone astronaut would have to be delivered to a specific site in the Atlantic Ocean where Navy ships would be waiting to retrieve him. The job of charting the mission's trajectory fell to Katherine, who had proven herself as a capable researcher and a reliable mathematician. "Let me do it," she told the NASA engineers. "Tell me when you want it and where you want it to land, and I'll do it backwards and tell you where to take off."

Using analytic geometry, Katherine figured out what the *Freedom 7* rocket's speed and altitude should be to reach both space and the splashdown location. With a flight achieving a peak altitude of 116 miles (187 kilometers) and a top speed of 5,180 miles (8,336 kilometers) per hour, Alan Shepard became the first American in space on May 5, 1961. Thanks to Katherine's calculations, Shepard was grinning aboard a Navy ship within eleven minutes of splashdown. His fifteen-minute spaceflight was considered a triumph and sparked President John F. Kennedy to call for the United States to land a person on the moon and return him safely to Earth by the end of the decade.

Early the following year, NASA was finally ready to attempt its first orbital flight. Katherine's equations would help determine the launch trajectory and flight path for the new mission, which would be much more complex than a simple parabola. Reaching orbital velocity would require greater speed and power—although acceleration could not be so rapid as to create gravitational forces, or g-forces, severe enough to leave the astronaut incapacitated.

By 1962, NASA had begun relying more on machines for complex calculations. A large but rather primitive computer by today's standards, the IBM 7090, plotted the complicated coordinates for the orbital flight path. But before astronaut John Glenn would launch aboard Mercury's powerful Atlas rocket, he had a demand for NASA's leadership: Katherine Johnson needed to review the computations. "If she says they're good, then I'm ready to go," he told them.

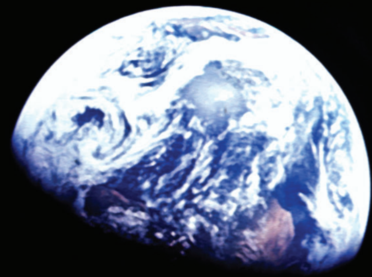


The path to the moon determined by Katherine and NASA engineers involved first launching the astronauts into Earth orbit before propelling the command module to the moon. Flight maneuvers had to be precisely timed, taking into account the constant motion of both Earth and the moon.

Using her desktop mechanical calculating machine, Katherine completed her computations for a spacecraft with three Earth orbits, launching from Cape Canaveral, Florida, and splashing down 800 miles southeast of Bermuda. Taking a day and a half to get through the equations, Katherine came up with numbers that matched those of the computer. *Friendship 7* launched on February 20, 1962. Reaching speeds of more than 17,000 miles (or 27,300 kilometers) per hour and lasting nearly five hours, the orbital spaceflight proved another NASA triumph, making John Glenn a national hero.

But it would be another six years before NASA gained the knowledge and experience needed to attempt a lunar mission. Through its Gemini program, engineers, technicians, flight controllers, and astronauts mastered completing rendezvous with other spacecraft, performing extravehicular activities in spacesuits, and traveling in space for up to two weeks at a time.

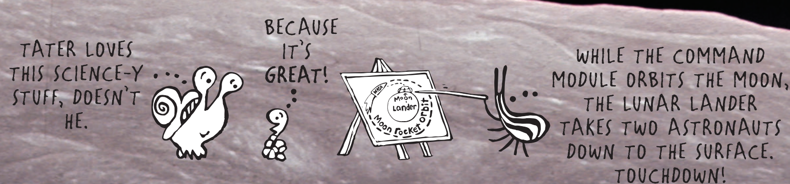
In December 1968, the United States boldly launched the Apollo 8 mission toward the moon. With three astronauts on board, its Saturn 5 rocket became the first to take human beings the 235,000 miles (378,200 kilometers) to the moon's orbit. In calculating the flight path, Katherine and NASA engineers had needed to aim the rocket not at where the moon was positioned at liftoff, but where it would be in three days, the time it would take the spacecraft to reach the moon. They also had to plan for several never-before-tried



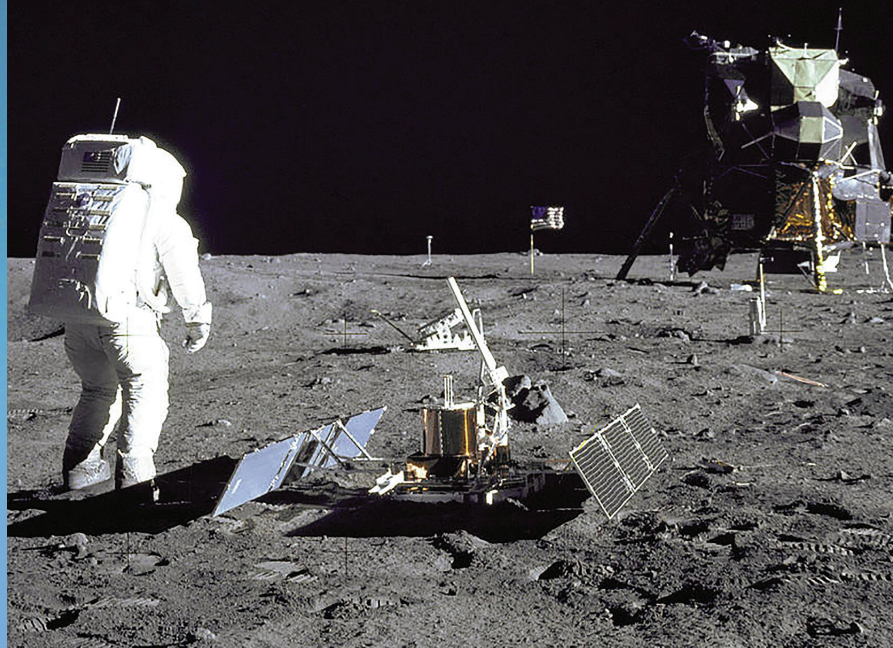
maneuvers, such as trans-lunar injection, or TLI, which would catapult the astronauts from Earth orbit toward the moon, and trans-Earth injection, or TEI, to propel them back toward Earth. Traveling at hypersonic speeds, the astronauts would need to approach Earth's atmosphere at a narrow angle, determined by Katherine, to avoid burning up during reentry. Apollo 8 successfully completed ten orbits of the moon before its three astronauts returned safely home.

For Apollo 11, the first attempted lunar-landing mission, a complex step would be added: full use of a lunar module. In NASA's approach to a moon landing, once the command module entered lunar orbit, a lunar lander would detach and travel down to the moon's surface carrying two of the astronauts. Katherine was called on to work out the exact time the lunar module needed to lift off from the moon in order to rejoin the orbiting command module for the return home. There was little room for error. Any deviation that didn't bring the modules together at the right moment could strand the lander and doom its two astronauts. "Everybody was concerned about getting them there," Katherine later said. "We were concerned about getting them back."

This awe-inspiring view of Earth was photographed as astronauts orbited the moon for the first time on Apollo 8.



On July 16, 1969, Apollo 11 launched with astronauts Neil Armstrong, Michael Collins, and Edwin "Buzz" Aldrin on board. Armstrong and Aldrin eventually entered the lunar module *Eagle,* which touched down on the moon on July 20. A few hours later, the two men achieved humanity's enduring dream of walking on the moon. Afterward, *Eagle* successfully docked with *Columbia,* the command module, and the three astronauts returned to Earth, splashing down in the Pacific Ocean southwest of Hawaii on July 24. All of Katherine's calculations had proved correct.



Apollo 11 astronaut Neil Armstrong took this photograph of Buzz Aldrin deploying scientific instruments not far from the *Eagle* lander.

Few people outside NASA and some black communities on the East Coast knew of Katherine's significant contributions. She continued to work on American space missions until 1986. "I loved every single day of it," she would say of her long career at Langley. "There wasn't one day when I didn't wake up excited to go to work."

In 2015, President Barack Obama personally awarded Katherine the Presidential Medal of Freedom. At the ceremony, he stated, "In her thirty-three years at NASA, Katherine was a pioneer who broke the barriers of race and gender, showing generations of young people that everyone can excel at math and science, and reach for the stars." Indeed, with her perseverance, intelligence, and hard work, Katherine overcame many obstacles and helped take her country—and the whole of humanity—all the way to the moon.

President Barack Obama awards Katherine Johnson the Presidential Medal of Freedom, America's highest civilian honor.