

# Katherine Johnson

“Hidden Figure” and NASA Pioneer

1918 - 2020

Mathematician

Space Program Trailblazer

“Human Computer”

Medal of Freedom Recipient

Inspiration to Women in STEM



*Katherine Johnson working as a NASA mathematician at the Langley Research Center in Virginia, c. 1966.*



## A Space-Age Computer

On July 20, 1969, astronauts Neil Armstrong and Buzz Aldrin walked on the **lunar** surface for about two and a half hours. Their safe trip to the moon and back was guided by fellow astronaut Michael Collins, piloting the command **module** in lunar **orbit**, and the onboard computer in both spacecraft, the Apollo Guidance Computer.

This computer was a technological marvel for its time, but it held just over 4KB of processing data (**RAM**) and 72KB of storage data (**ROM**).

In contrast, modern smart phones have about 4GB of RAM and as much as 500GB of ROM – over 7 million times the data capacity of computers astronauts used to reach the moon.

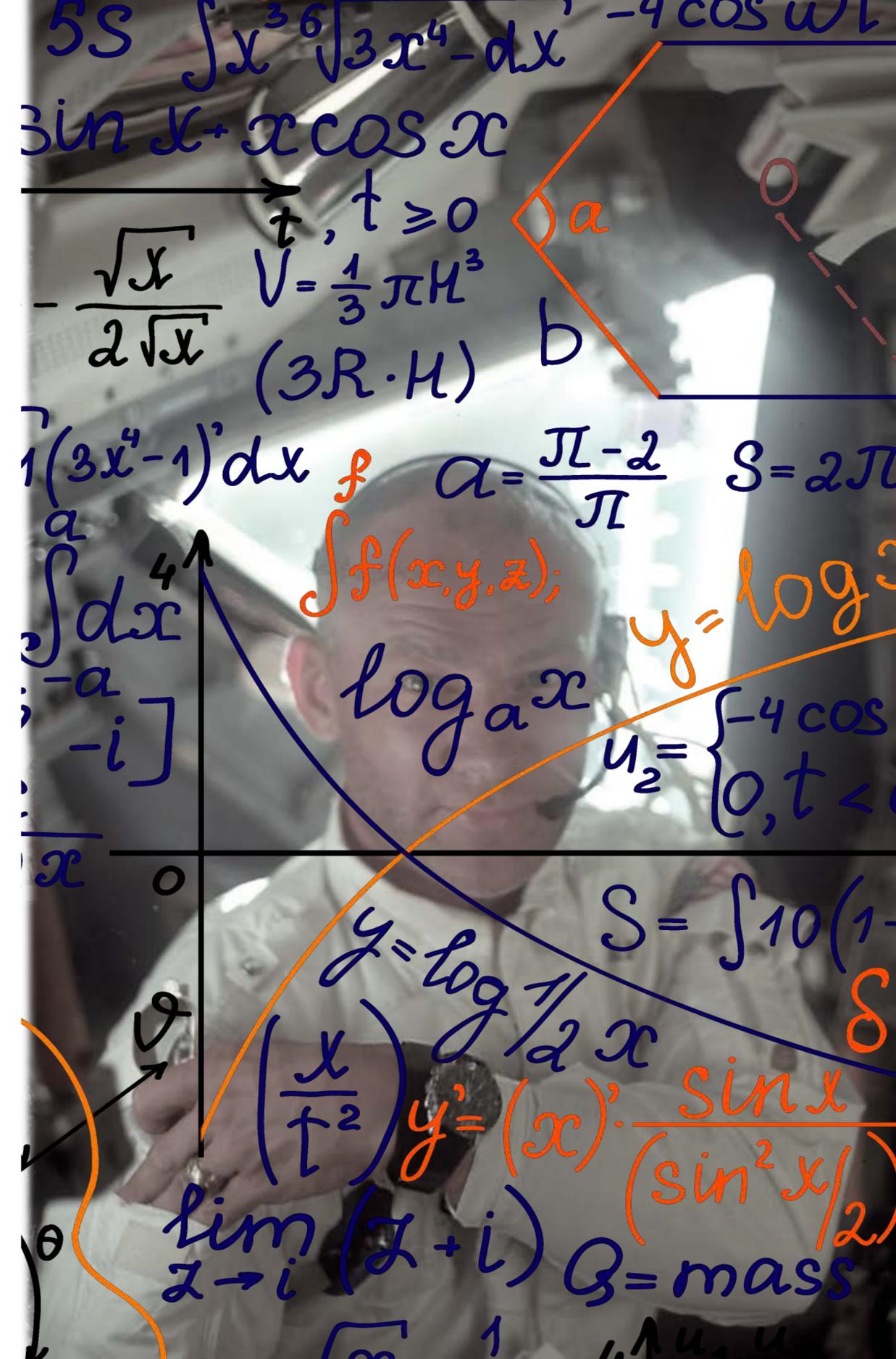




# A Space-Age Computer

How did the National Aeronautics and Space Engineering Administration (NASA) accomplish so much with far less computing power than a modern graphing calculator?

They were powered by decades of painstaking work by an incredible team of engineers, physicists, and mathematicians. One of these figures was **Katherine Johnson**.



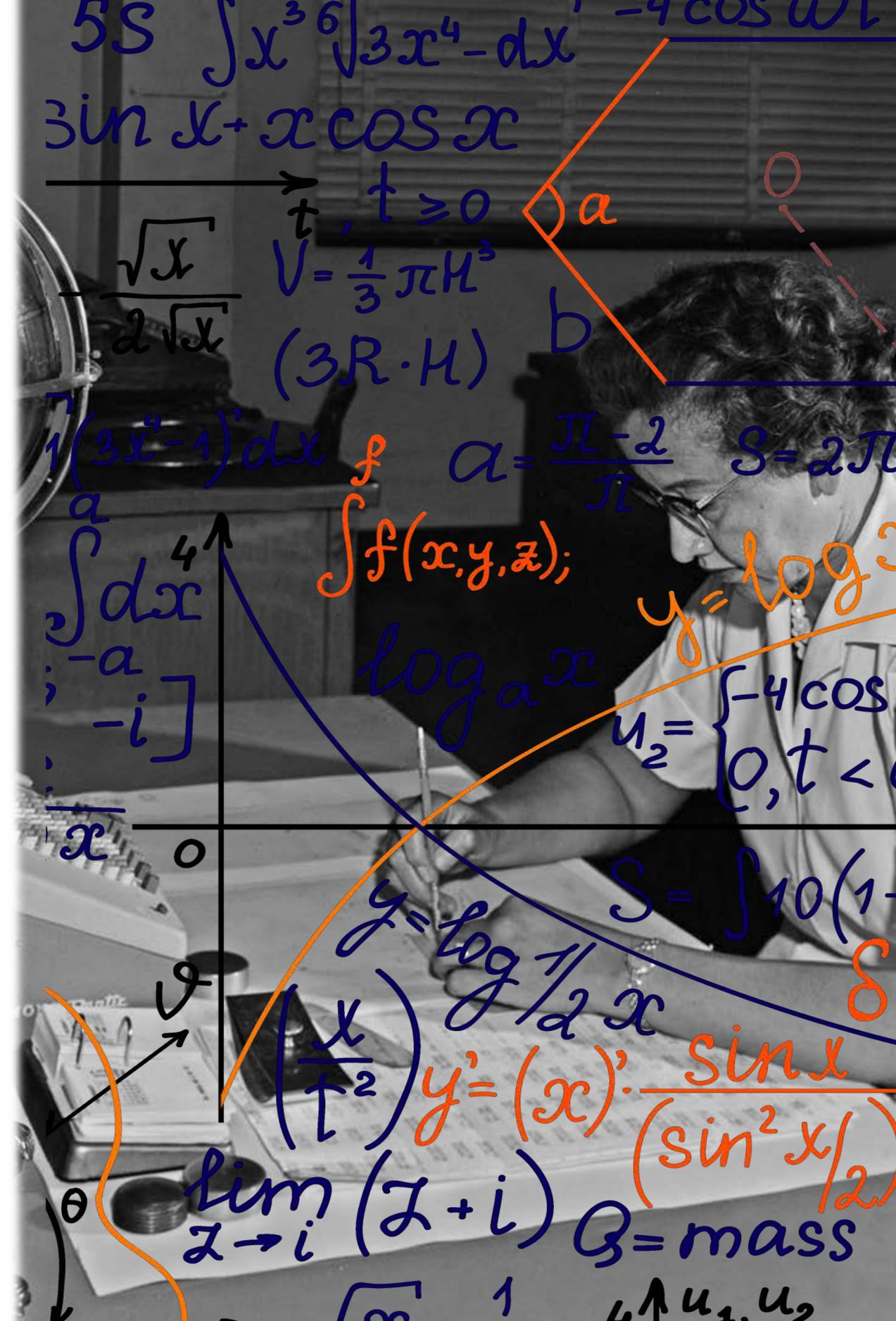
$5S \int x^{3.6} \sqrt{3x^4} dx$   
 $3 \ln x + x \cos x$   
 $\frac{\sqrt{x}}{2\sqrt{x}}$   
 $V = \frac{1}{3} \pi R^2 h$   
 $(3R \cdot h)$   
 $\int (3x^4 - 1) dx$   
 $\int dx$   
 $\int_a^b f(x,y,z)$   
 $\log_a x$   
 $y = \log x$   
 $u_2 = \begin{cases} -4 \cos \\ 0, t < \end{cases}$   
 $S = \int 10(1 - \delta)$   
 $y = \log \frac{1}{2} x$   
 $\left(\frac{x}{t^2}\right) y' = (x)'$   
 $\frac{\sin x}{(\sin^2 x / 2)}$   
 $\lim_{z \rightarrow i} (z + i)$   
 $Q = \text{mass}$

# A Human Computer?

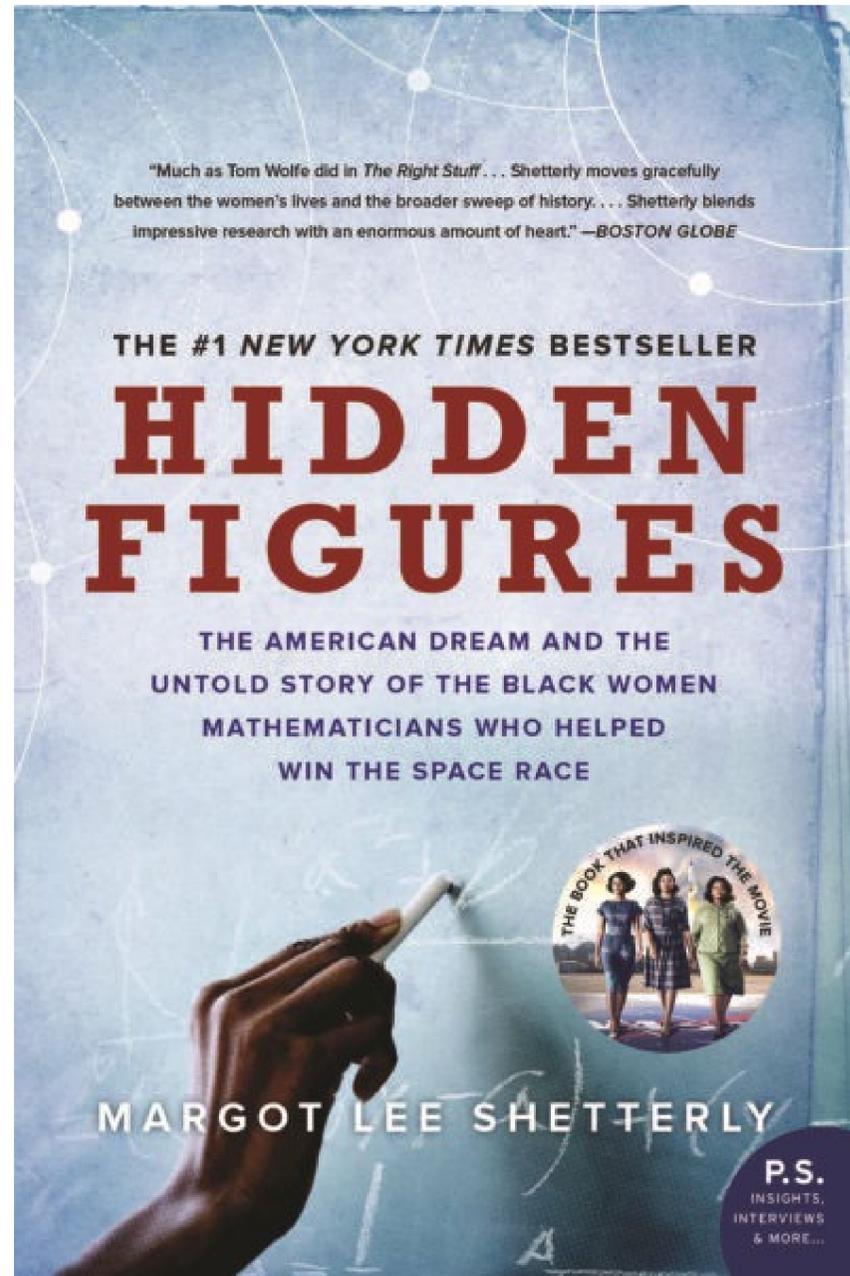
Born Creola Katherine Coleman in White Sulphur Springs, West Virginia, in 1918, Johnson's gifted mind, supportive family, and strong work ethic led her on an extraordinary journey from a humble childhood to NASA's breakthrough Mercury and Apollo programs.

Her first job in the space program was as a computer – a word which originally meant “a person who performs computations.” Johnson went on to spend over three decades at NASA, earning great respect for her achievements as a research mathematician.

Johnson performing manual calculations at NASA, c. 1962.



# A Once “Hidden Figure” Revealed



Throughout her career, Johnson received many **accolades** from colleagues and spoke widely to students about math and science.

But after the publication of *Hidden Figures*, a book about Black female computers in the early years of NASA – like Johnson and her colleagues, mathematician Dorothy Vaughn and aerospace engineer Mary Jackson – Johnson has been hailed as an American icon and an inspiration.

# A Once “Hidden Figure” Revealed



Unlike many of her colleagues, Johnson lived to see her achievements receive international attention. She lived to the remarkable age of 101, and her final years were filled with long-overdue celebrations in her honor.

But the greatest tribute to Johnson lies in the extraordinary success of the space program during her tenure, and in the work of later generations of women and African Americans who followed in her footsteps.



# Young Math Prodigy

Johnson was in love with numbers from the time she was a girl. “I counted everything,” she said later. “I counted the steps to the road, the steps up to church, the number of dishes and silverware I washed ... anything that could be counted, I did.”



*Young Katherine Johnson, c. 1930s*

Her parents, Joshua and Joylette, resolved early on that their **precocious** daughter would have every opportunity to develop her God-given talents. In the age of segregation, that meant finding a school that would educate Black students beyond the 8<sup>th</sup> grade. The nearest was 120 miles away in the town of Institute, West Virginia. Joshua made the long drive regularly, and the family divided their time between White Sulphur Springs and Institute for many years.

# Education at West Virginia State College

Johnson's high school education took place on the campus of historically Black West Virginia State College. After earning her high school diploma, she enrolled in the college.

When it became clear that Johnson was sweeping through her undergraduate math courses with ease, professor W. W. Schieffelin Claytor took the young prodigy under his wing.



*Women of West Virginia State College in its days as an all-Black college. Exact date unknown, c. 1940 or 50s.*

**What opportunities likely presented themselves to Johnson at WVSC, then an all-Black university? What would have been the limitations of such an environment?**

## Math Mentor: W.W. Schiefflin Claytor

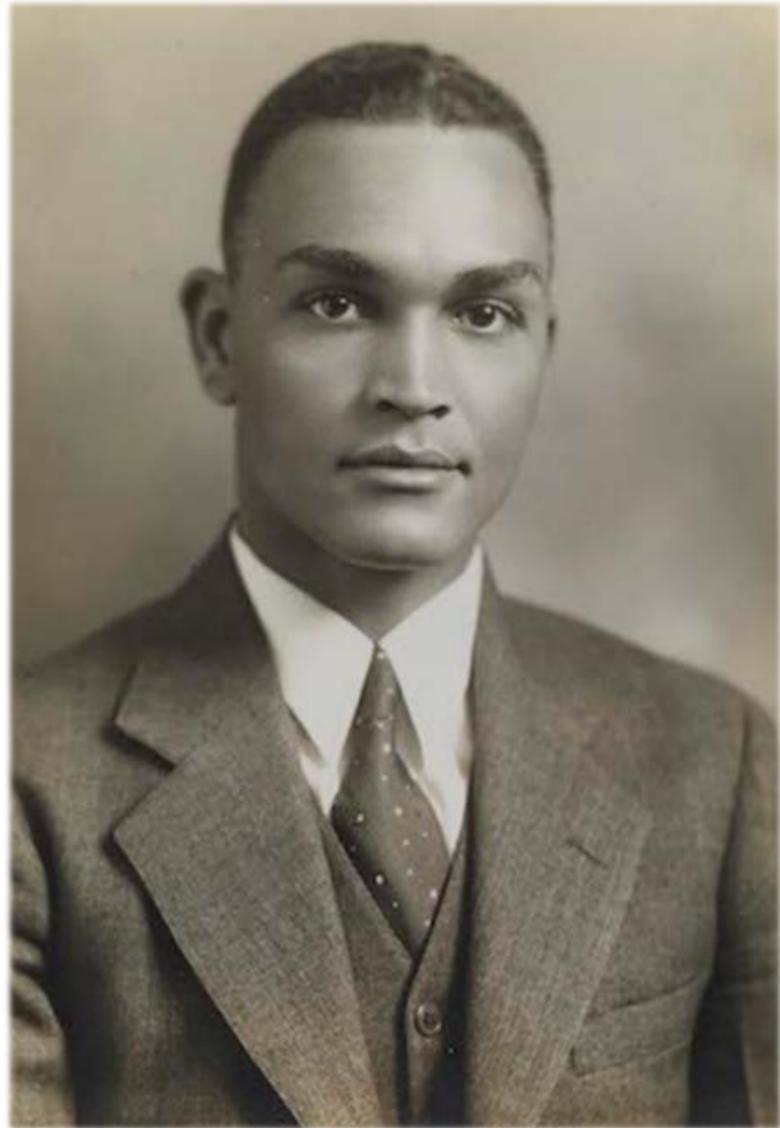


*William W. Schiefflin Claytor,  
c. 1930.*

Claytor became Katherine Johnson's mentor and showed her the way to a potential career in mathematics.

Claytor was only the third African American to earn a mathematics Ph.D., at the University of Pennsylvania in 1933. He won a Rosenwald Fellowship – a prestigious grant for Black intellectuals and activists – to study at the University of Michigan, but racist policies kept him out of top academic positions, even in the North.

## Math Mentor: W.W. Schiefflin Claytor



*William W. Schiefflin Claytor,  
c. 1930.*

Throughout her education, Claytor spoke frankly to young Johnson about the difficulties she would face finding a job in mathematics. Later in life, Claytor served in the U.S. Army during WWII, and went on to a teaching career at Howard University.

Just as Johnson would later break down racial and gender barriers in STEM, Claytor's earlier battles against discrimination and widespread racism made Johnson's education possible.



# Youth in Segregated West Virginia



Katherine Johnson  
in her 20s.

Over 70 years later, Johnson would reflect on the challenges she faced in the Jim Crow era, especially the limits segregationist laws tried to place on her education:

*“[I]n its 1896 Plessy v. Ferguson decision, the Supreme Court legalized ‘separate but equal’ facilities that were segregated by race. But everyone knew that separate also meant unequal ... Despite these considerable obstacles, [we] fought for our rights and took pride in our achievements. We engaged in self-help, educated ourselves and one another, and fought against laws and racial violence set up to oppress us and keep us ‘in our place,’ as many White people described our inferior position in American society.”*

# Integrating West Virginia University

While West Virginia was less aggressively racist than states in the South, Johnson's schooling was still severely curtailed. Without the dedication of her parents, pivotal opportunities would have been closed to her, regardless of her obvious gifts.

In 1939, Johnson had the chance to enroll in a graduate math program – and integrate higher education in West Virginia. She and two men became the first Black students to attend the state's flagship school, West Virginia University. But after the first semester, Johnson left the university to focus on building a family with her first husband, James Goble.

*Statue of Katherine Johnson on the campus of West Virginia State University in Institute, unveiled in 2018 on the eve of her 100th birthday.*



# Integrating West Virginia University

**What people, events, or images do you associate with efforts to racially integrate schools? What kinds of opposition did Katherine Johnson likely face?**

**What would motivate a student as gifted as Johnson to leave the university and pursue home life? How are women who prioritize family over career seen in our culture today?**

*Statue of Katherine Johnson on the campus of West Virginia State University in Institute, unveiled in 2018 on the eve of her 100th birthday.*



# Family and Teaching

Katherine and James had three daughters: Constance, Joylette, and Katherine, all of whom were encouraged by their parents to value math and science.

Johnson worked as a schoolteacher once her children were older; even after her career at NASA, she kept a love of teaching, sharing her experiences in the space program with students across the nation.



*Johnson and her daughters, c. 1940s.*

# Family and Teaching

In 1952, she heard from a friend that the National Advisory Committee for Aeronautics (NACA) was hiring Black mathematicians at their Langley Memorial Aeronautical Laboratory in Virginia.

The family moved to nearby Newport News, and Johnson joined the pool of “computers” at Langley in summer of 1953.

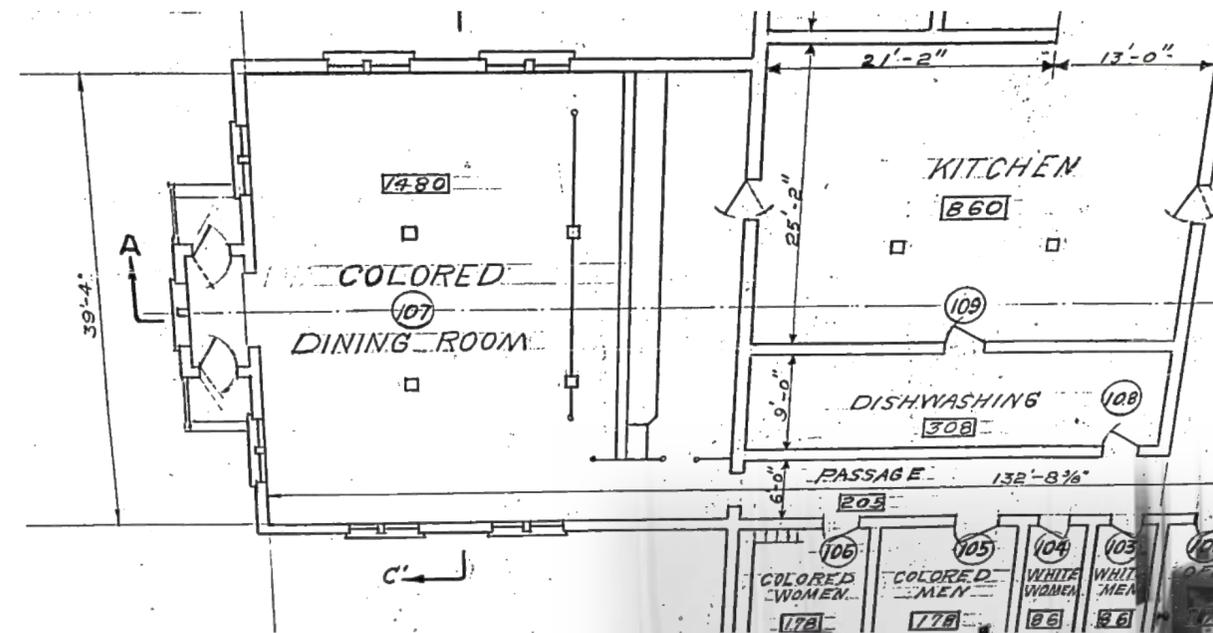


*Johnson and her daughters, c. 1940s.*

# 1953: “Computers Who Wear Skirts”

NACA recruited women – some of them right out of high school – to perform the difficult, often tedious manual calculations necessary before the advent of “computational machines.” This was a time, Johnson later joked, “when the computer wore a skirt.”

Because Langley was in Virginia, the facility was officially segregated. Johnson ignored these rules, using the same restroom as her White colleagues and attending meetings that had only been attended by White men. She wrote in her autobiography:



*The plans for Langley’s segregated facilities, with “colored” dining area and rest rooms; female computers at work.*



# Crunching the Numbers



Portrait of Katherine Johnson from NASA.gov, c. 1960s

*“I didn't allow their side-eyes and annoyed looks to intimidate or stop me ... I just ignored the social customs that told me to stay in my place.”*

At NACA, Johnson reported to Dorothy Vaughan, head of Langley's West Area for Black computers. After two weeks Johnson was pulled from the pool, at Vaughan's suggestion, and assigned to the Guidance and Control branch, a team of White male engineers.

# Crunching the Numbers



*Portrait of Katherine Johnson from NASA.gov, c. 1960s*

The position was meant to be temporary. On her first day, Johnson caught an error in her colleagues' calculations. She quickly became a permanent member of the team.

Johnson and her children were devastated by her husband's death from a brain tumor in 1956. Johnson threw herself into her work. While at Langley, Katherine met Colonel James Johnson; they married in 1959, and were together for six decades, until his death in 2019.



# The Space Race

The technological battle known as the “space race” between the U.S. and its **Cold War** rival, the Soviet Union, began in 1957 when the Soviets successfully launched the first-ever satellite, *Sputnik 1*, into the Earth’s orbit.

Government leaders and the American public experienced “Sputnik shock,” upending assumptions about the nation’s scientific superiority.

*Soviet satirical newspaper KROKODIL (Crocodile) showing two “sputniks” – Russian for “satellites” – with tickets for space travel. The caption reads: “Who’s last? I’m behind you!” November 20, 1957.*

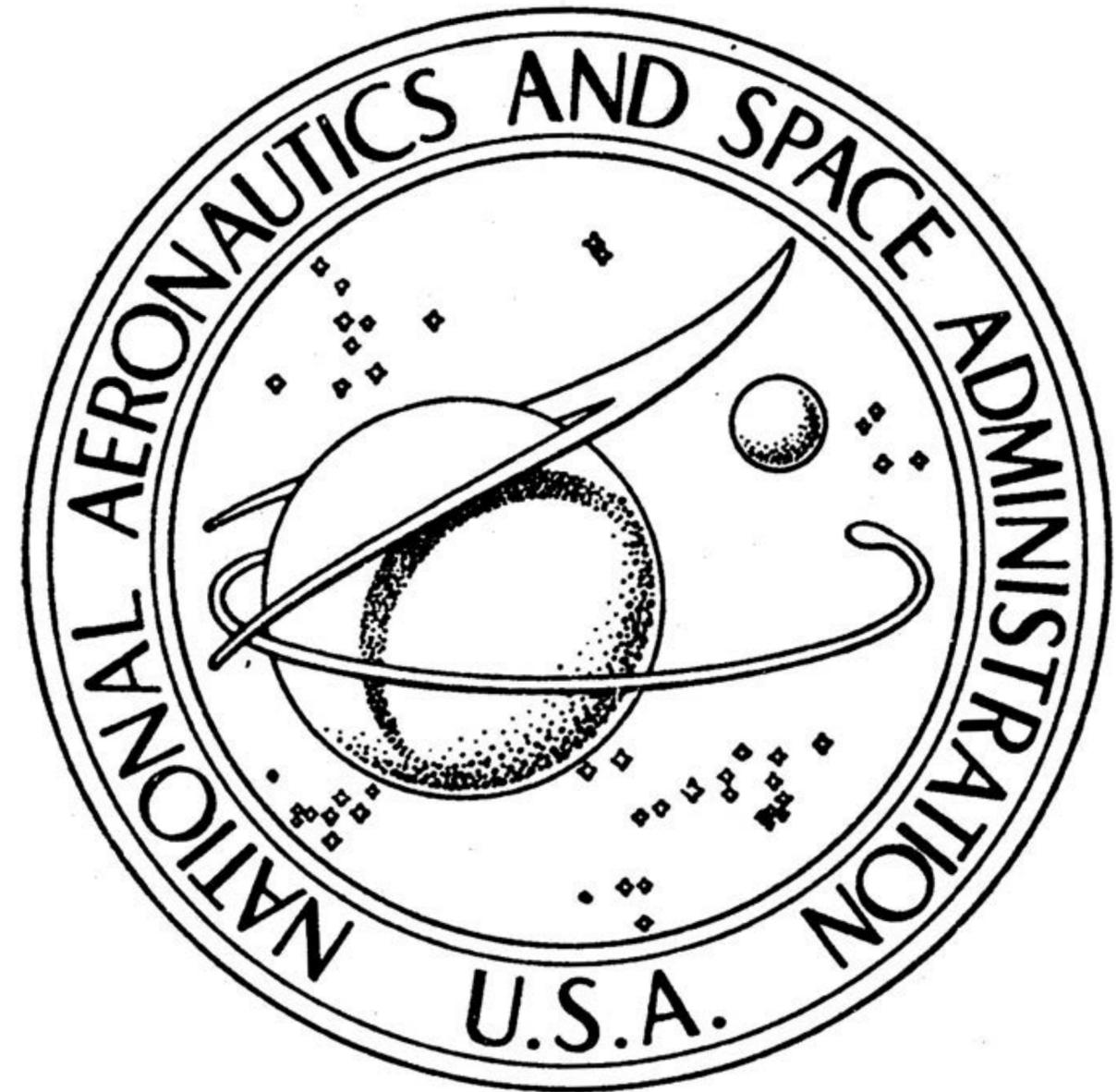




# The Space Race

In response, NACA became NASA, and the agency officially desegregated. Johnson began work at NASA as an aerospace technologist, just as it launched Project Mercury, dedicated to human space flight.

Mercury's mission was to put a manned space flight into the Earth's orbit – preferably before the Soviet Union accomplished the same goal with its similar Vostok program.



1959 NASA insignia

# Project Mercury

Johnson's knowledge of analytic geometry made her an invaluable member of the Space Controls Branch, which charted a safe flight into orbit and back. Johnson also made other contributions to scientific knowledge; in 1960, she co-authored a technical paper on satellite positioning, the first of many she wrote for NASA.

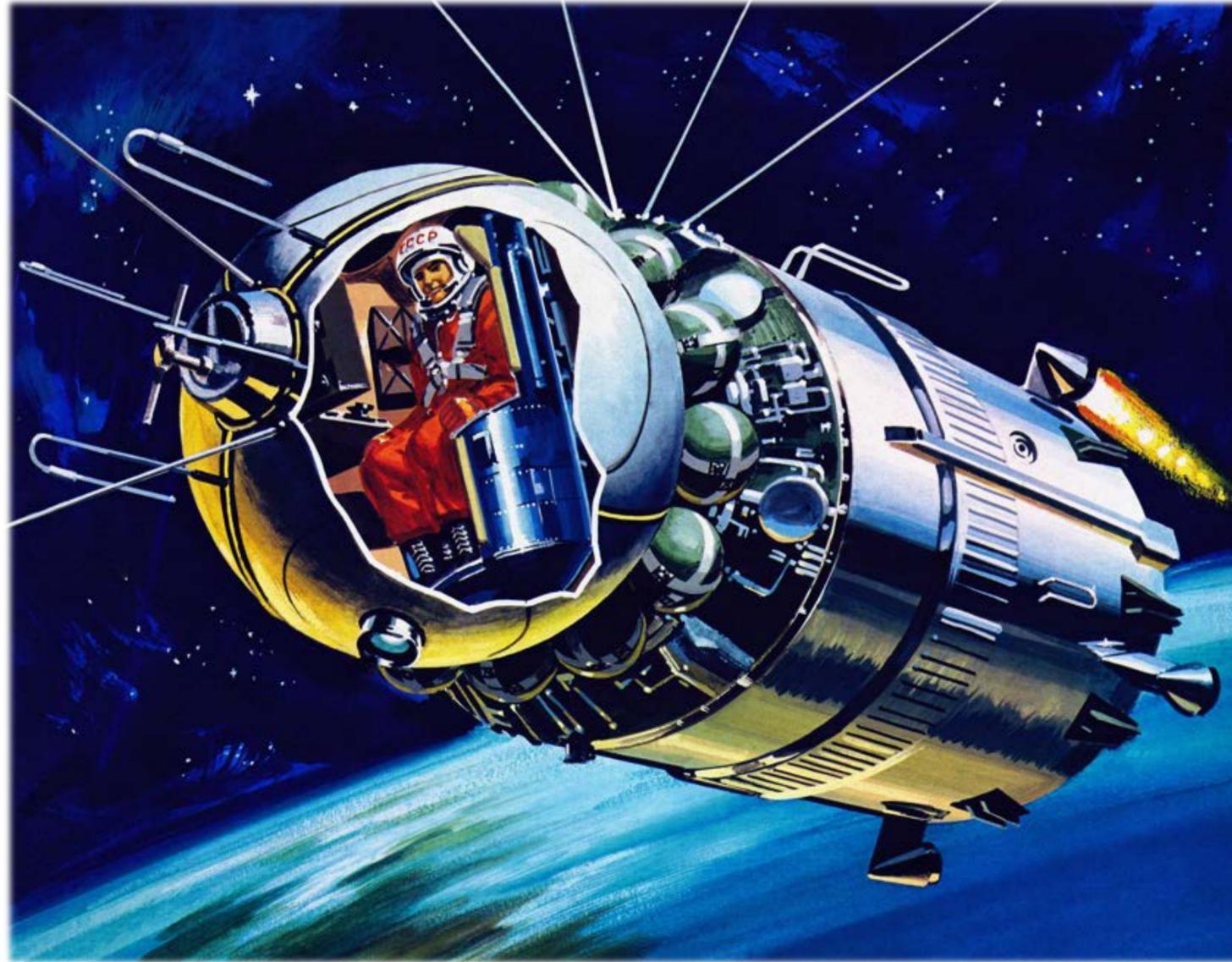
She recalled those early years of the space program and its spirit of innovation:

*"We wrote our own textbook, because there was no other text about space. We just started from what we knew. We had to go back to geometry and figure all of this stuff out. Inasmuch as I was in at the beginning, I was one of those lucky people."*



*Katherine Johnson at her desk in the early 1960s.*

# 1961: First Men in Space



On April 12, 1961, a few weeks after Mercury launched a successful unmanned test mission, the Soviets shocked the world by launching *Vostok 1*, the spacecraft piloted by cosmonaut Yuri Gagarin.

*Illustration of Yuri Gagarin in the Vostok 1, from Je sais tout magazine, May 20, 1969*

# 1961: First Men in Space



*Soviet cosmonaut Yuri Gagarin, first man in space; and American astronaut Alan Shepard, first American in space.*

Gagarin became the first man in space, orbiting the Earth once. Now the pressure was on for NASA to outshine its Soviet counterpart.

The flight of Alan Shepard, who would become the first American in space, was scheduled for May. Johnson was responsible for the long, difficult work of calculating (and re-calculating) the trajectories for his flight.



## Shepard's Flight

Johnson later recalled of the mission:

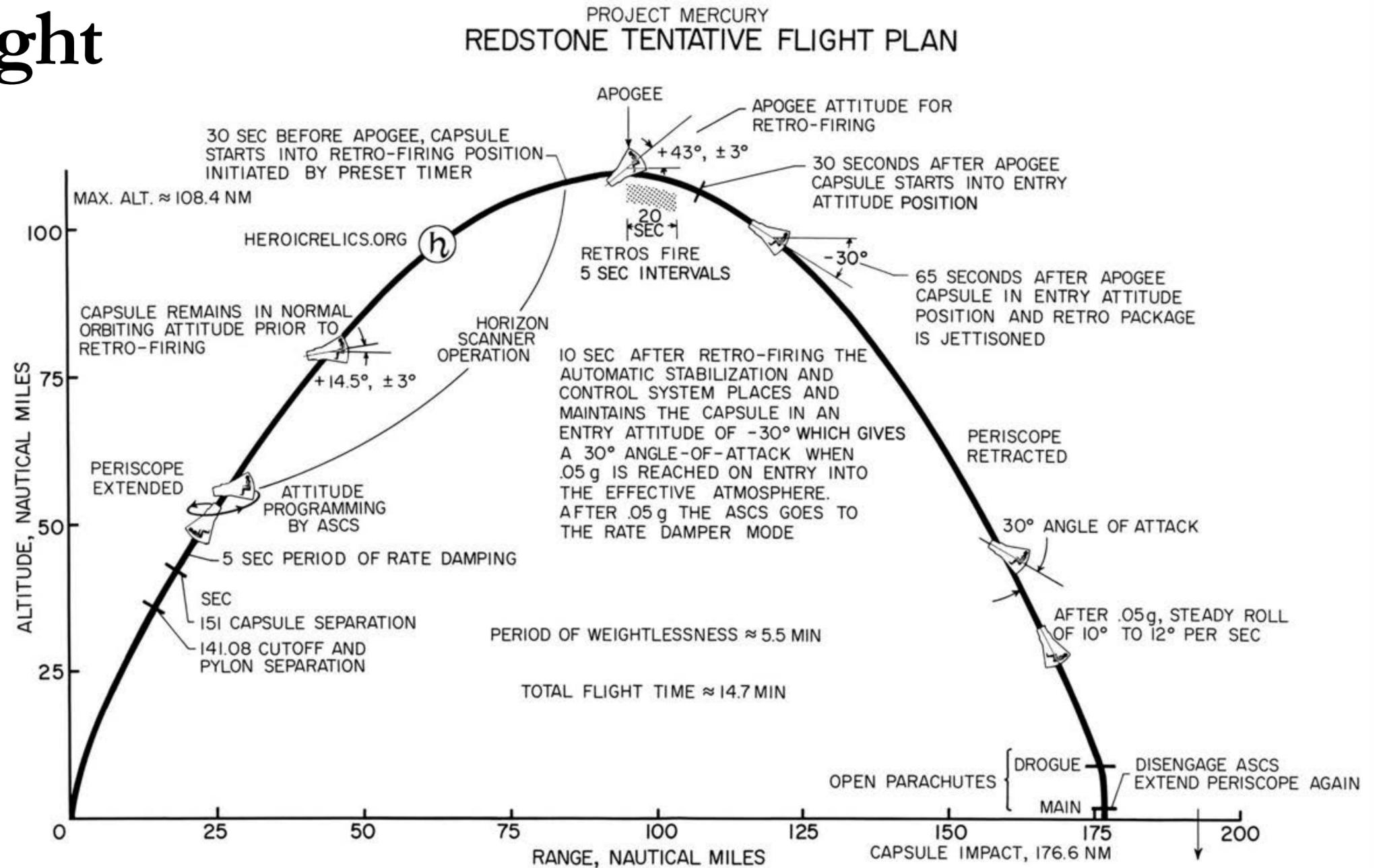
*“The early **trajectory** was a **parabola**, and it was easy to predict where it would be at any point Early on, when they said they wanted the capsule to come down at a certain place, they were trying to compute when it should start...”*

*NASA's retroactive Project Mercury logo, designed for the astronaut memorial in 1964.*



# Shepard's Flight

"... I said, 'Let me do it. You tell me when you want it and where you want it to land, and I'll do it backwards and tell you when to take off.' That was my forte."



*Project Mercury Tentative Flight Plan. Developed by the Space Task Group, Langley Field, Virginia: June 10, 1959. "Redstone" was the name of the series of rockets that carried the Mercury capsules into space.*



## 1962: “Get the Girl”

The technological advances launched by the space race had also rapidly accelerated the development of *mechanical* computers. The human computers’ labor had helped to make their positions obsolete!

These new computers, used for the next Mercury flight, John Glenn’s 1962 Friendship 7 mission, were programmed with the necessary equations to take his capsule into orbit and safely back to Earth’s surface. But the astronaut didn’t trust this untested technology with his life. Glenn wanted a human to double-check the calculations. “Get the girl,” he said. “If she says they’re good, then I’m ready to go.”



*Astronaut John Glenn gives the “ready” sign during Mercury-Atlas 6 pre-launch training activities, 1962.*



# 1962: "Get the Girl"

The "girl" was Johnson, who diligently repeated the machine's math with her desktop calculator.

Glenn's flight was a success; he orbited the Earth three times before splashing down in the Atlantic.

*Article on Johnson's role in the success of Project Mercury, Pittsburgh Courier, March 10, 1962.*

## The Story of Katherine Johnson

# Lady Mathematician Played Key Role in Glenn Space Flight

HAMPTON, Va.—She's a native of West Virginia's rolling foot-hills! She comes from picturesque White Sulphur Springs, where the world-famous Greenbriar Hotel is located. She's a graduate of W. Va. State College, where she graduated as a mathematics major under James C. Evans, currently civilian aide to the Secretary of Defense.

## Travel Bias Ruled Out

# A Way of Life Ends In South

WASHINGTON, D. C. — What is the real meaning of the latest decision rendered by the U. S. Supreme Court?

It means just what it said: "We have settled beyond question that no state may require racial segregation of interstate or intrastate transportation facilities."

The language is sharp, clear, precise!

The brief, unanimous opinion ordered a Federal Court in Mississippi to uphold promptly the right of Negroes to unsegregated transportation service.

The decision tells not only Mississippi, but Alabama, South

to those state and local laws which compelled segregation in restaurants, on trains and buses, interterminal waiting rooms and on city street cars in the deep South.

THE OPINION was one of the shortest on record. It marks a trend whose implications just cannot be ignored.

It says to the South—"You've been getting away with this thing for too long. We have decided to put a halt to it . . . NOW!"

Dixie's "die-hards" are stunned . . . but the walls are closing in, and they have no place to go.

—Max for Your Money in The Courier—

She continued her mathematical studies at the University of West Virginia in Morgantown, and today ranks as one of the most brilliant mathematicians of the present era. She is an expert on electronic IBM computers.

Her name . . . in case you haven't already guessed it . . . is Katherine Johnson; mother, wife, career-woman!

Mrs. Johnson is credited with helping to devise the highly complex tracking system which enabled scientists to predict . . . within TWO miles, the location of Lieut. Col. Glenn's rocket cone upon its return to earth after three orbits around the world.

She is co-author . . . September, 1960 . . . of the NASA Technical Note, D-233, Subject: "Determination of Azimuth Angle at Burnout For Placing a Satellite Over a Selected Earth Position."

BROKEN DOWN into plain, understandable English, it means that Mrs. Johnson, co-authored the paper which tracked the rocket cone upon its re-entry into the earth's atmosphere.

Mrs. Johnson is listed as a top security mathematician at Langley Field, Va., not far from Hampton, Va., where she lives with her talented daughter and Artillery captain husband.

It is said that Mrs. Johnson spent nearly six months making the calculations which eventually

# 1969: Project Apollo and the Moon Landing



Johnson's calculations were also critical to a high point of NASA's manned flights: the first lunar walk. In the Space Mechanics Division, she crunched the numbers for Apollo 11's successful moon landing on July 20, 1969. Her work helped **synchronize** the lunar lander with the command module orbiting the moon.

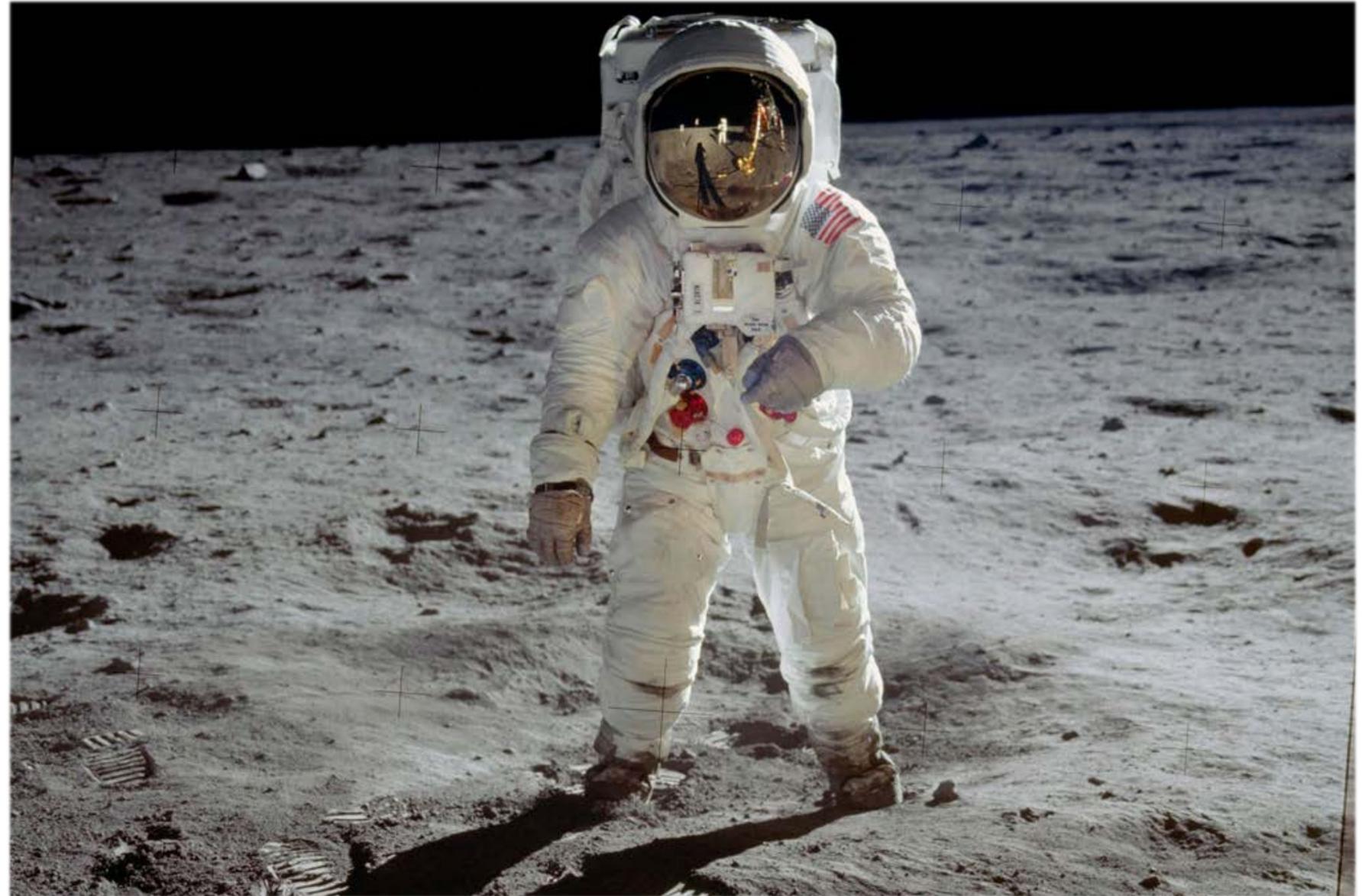
Johnson was at a reunion of her sorority in the Pocono Mountains during the landing and like most Americans, watched it on television. Johnson was confident in her calculations – she had run and re-run the numbers – but still nervous. “Anything could happen,” she said later.

“One small step for a man, one giant leap for mankind”:  
*Buzz Aldrin exits the Apollo 11 lander to take his first steps on the moon.*

# 1969: Project Apollo and the Moon Landing

But the landing and return to Earth were a triumph.

Johnson considered her trajectory calculations for Apollo 11 her greatest professional accomplishment.



*Famous photo from the Apollo 11 mission of Buzz Aldrin on the moon, taken by Neil Armstrong, with the reflection of Armstrong and the Lunar lander reflected in Aldrin's visor.*

# 33 Years of Happiness



*Johnson working at a computer terminal in Langley, c. 1980.*

Johnson worked on many projects for NASA until her retirement in 1986. “For 33 years,” she later recalled, “I went to work every day happy.”

In the decades after her retirement, Johnson lived a quiet life among family and friends in Newport News, Virginia. An active member Carver Memorial Presbyterian Church, she was humble about her accomplishments. Her pastor recalled knowing Johnson for years before learning the extent of her work for NASA.

**Johnson worked at NASA from 1953 to 1986. In those three decades, what cultural, technological, and political changes did the U.S. experience?**

## 2015: Presidential Medal of Freedom

In retirement, Johnson often spoke to schoolchildren about her accomplishments and the importance of math and science. Though she was honored by NASA colleagues and her alma mater, WVSU, she was far from a household name. But that was about to change.

In 2015, The White House awarded her the Presidential Medal of Freedom, representing “an especially meritorious contribution to the security or national interests of the U.S., world peace, cultural or other significant public or private endeavors.”



*November 24, 2015: Johnson receives the Medal of Freedom from President Barack Obama.*

## 2016: *Hidden Figures*



Meanwhile, writer and entrepreneur Margot Lee Shetterly had been researching the Black women who served as computers in the early space program.

Her research became the bestselling book *Hidden Figures*, in which Johnson was a central character.

*Hidden Figures* author Margot Lee Shetterly.

## 2016: *Hidden Figures*

The film adaptation of *Hidden Figures* was developed alongside its source material and released with the book. Along with the usual **dramatic license**, the award-winning film condenses many mathematical procedures that took weeks into a matter of hours. But it captures the pioneering spirit of the early space program and the thrill of the first Mercury missions.

Shetterly also created The Human Computer Project, ensuring that the work of NASA's computers is preserved for future researchers and historians.

*International poster for the acclaimed film adaptation of Shetterly's book Taraji P. Henson, center, plays Johnson.*



## 2016: *Hidden Figures*



*The stars of Hidden Figures, Taraji P. Henson, Octavia Spencer, and Janelle Monáe, with Yvonne Cagle and Katherine Johnson during the 2017 Academy Awards ceremony.*

At the 2017 Oscars, Johnson was honored during the presentation of the award for Best Documentary (alongside the stars of the movie and escorted by African American astronaut Yvonne Cagle).



# Death and Legacy



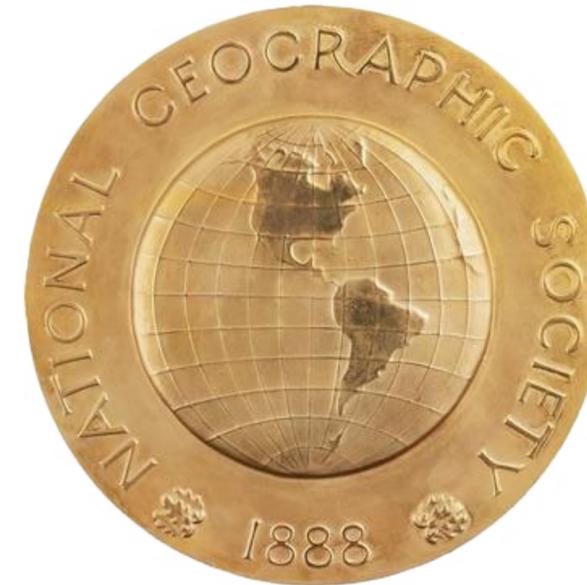
*Katherine Johnson, age 99, outside the new facility named in her honor in 2017.*

In September 2016, NASA dedicated the Katherine G. Johnson Computational Research Facility with a ribbon-cutting ceremony attended by Johnson and her family, friends, and students from Black Girls Code and 21<sup>st</sup> Century Community Learning Centers, organizations that work to broaden opportunities in the sciences.

The 23-million-dollar, **state-of-the-art** facility at Langley serves as an intellectual center for all those research mathematicians who follow in Johnson and her colleagues' footsteps.



# Death and Legacy



In 2020, the year of Johnson's death at age 101, the National Geographic Society awarded her the Hubbard Medal – the same honor it awarded the Apollo 11 astronauts in 1969.



# Katherine Johnson's Century

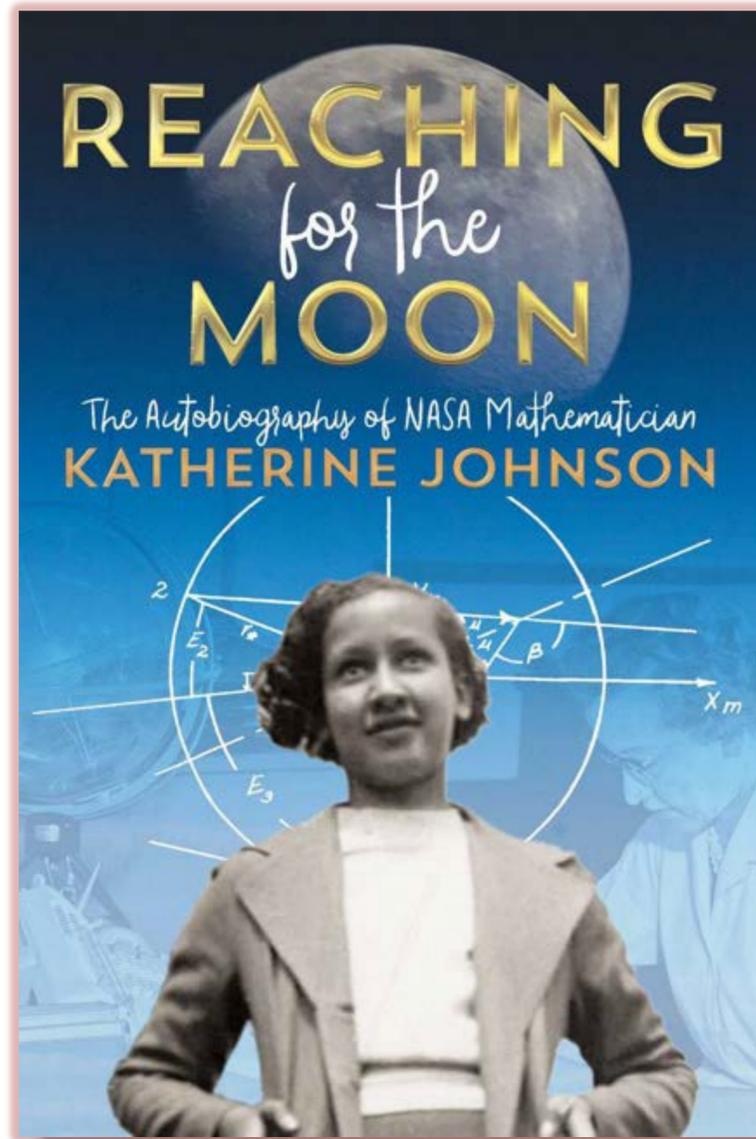


Reaching for the Moon, Katherine Johnson's autobiography written for young people.

Katherine Johnson was born into an America where state-sanctioned racism was accepted as normal, where women were discouraged – if not barred – from working in science and engineering, and where the idea of space travel seemed the stuff of fantasy.

When she died, the country she served had officially **repudiated** racial and gender discrimination and raised its flag on the moon.

# Katherine Johnson's Century



In a 2018 interview, she offered these words of advice to those who come after her:

*“Follow your passion. Whatever you’re doing, do your best at all times and make it as correct as possible. Work as if someone is watching you. Then you’ll be prepared when an opportunity presents itself. And you’ll have the answers.”*

Reaching for the Moon, Katherine Johnson's autobiography written for young people.





# Vocabulary

accolades  
Cold War  
cosmonaut  
dramatic license  
lunar  
module  
orbit  
parabola  
precocious  
RAM  
repudiate  
ROM  
state-of-the-art  
synchronize  
trajectory



Katherine Johnson, photographed by Annie Leibowitz for *Vanity Fair* in 2016.



WOODSONCENTER