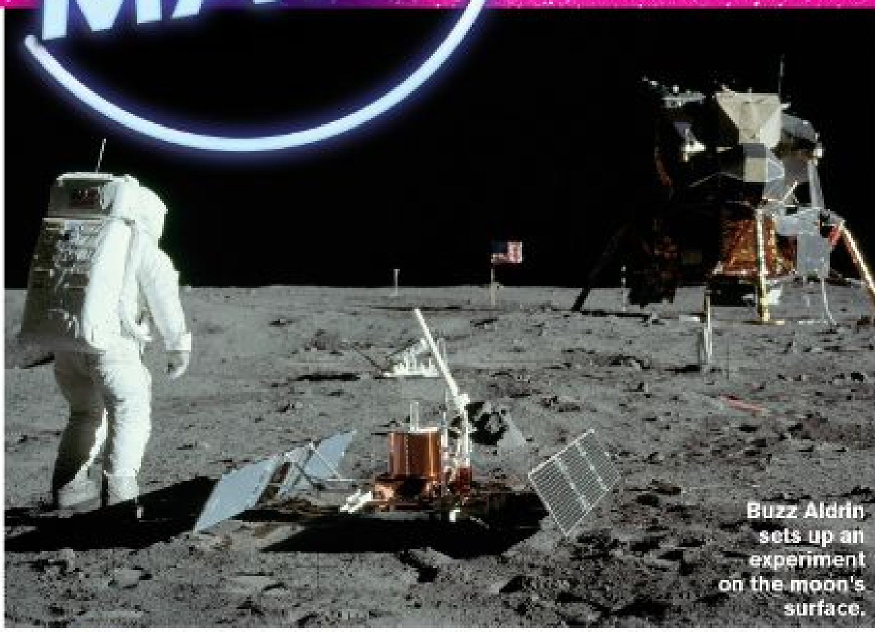
Moon MATH

More than 40 years ago, this woman's calculations got astronauts to the moon and back



Buzz Aldrin sets up an experiment on the moon's surface.

Astronauts Neil Armstrong and Buzz Aldrin made history when they became the first humans to set foot on the moon on July 20, 1969. The Apollo 11 mission was the result of decades of research, hundreds of scientific experiments, and the work of tens of thousands of dedicated people.

But the contributions of one woman outshined the rest: Katherine Johnson. She was a NASA mathematician who calculated the detailed flight path the spacecraft would take from Earth to the moon. This month, a movie about Johnson and NASA's other black female mathematicians hit theaters. Titled *Hidden Figures*, it's based on a book of the same name.

To truly appreciate Johnson's achievements, it's necessary to understand the world she lived in. Johnson is black, and grew up during a time when segregation, or separating people by skin color, was legal in much of the South. African-Americans were forced to use separate bathrooms, attend separate schools, and eat at separate restaurants.

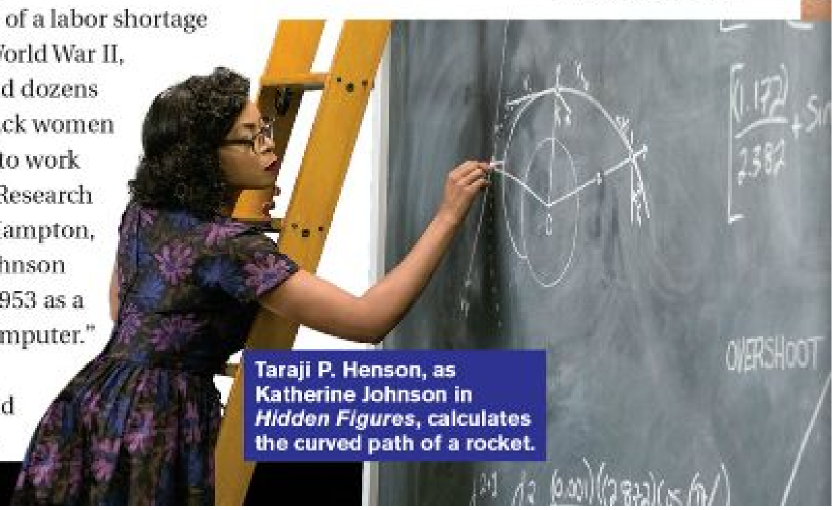
Because of a labor shortage following World War II, Johnson and dozens of other black women were hired to work at Langley Research Center in Hampton, Virginia. Johnson started in 1953 as a "human computer." In this job, Johnson and her female colleagues crunched the numbers in the equations used to design, test, and fly planes and spacecraft reliably and safely. Some equations had up to 35 variables! Together, their results helped launch rockets into space and safely transport astronauts into space—and back home again.

Getting astronauts Armstrong and Aldrin to the moon was a spectacular scientific achievement. Getting them home was another hurdle. The astronauts had a small window of only a few hours to blast off from the moon's surface and reconnect with the Apollo shuttle for the return journey. It was Johnson's job to figure out the precise time that the two space vehicles should connect. This was a very complicated task, but one that Johnson considered her greatest contribution to the space program.

"I found what I was looking for at Langley," says Johnson, who is now 98 years old. "I went to work every day for 33 years happy. Never did I get up and say, 'I don't want to go to work.'"

—*Alexa C. Kurzius*

Meet one of NASA's "human computers." VIDEO



Taraji P. Henson, as Katherine Johnson in *Hidden Figures*, calculates the curved path of a rocket.

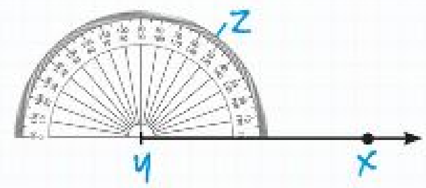
DRAWING ANGLES WITH A PROTRACTOR

When planning the Apollo 11 voyage, NASA scientists made a flight plan for the trip, including a step-by-step process to get the moon lander to the appointed spot on the surface. Katherine Johnson and her team calculated a series of angles for the moon lander to make before its descent. An angle is a figure made by two rays (a line with one endpoint) that meet at a point called a vertex. The difference between the two lines is measured in degrees.

EXAMPLE: Draw an angle of 52°.

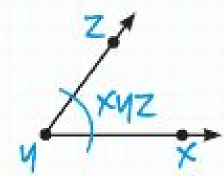
Step 1 Draw a ray and label the endpoint *Y* and add another point on the ray labeled *X*:

Step 2 Align the baseline of your protractor with the ray. Point *Y* should be at your protractor's origin. Make a point along the scale of the protractor at 52° and label it *Z*:



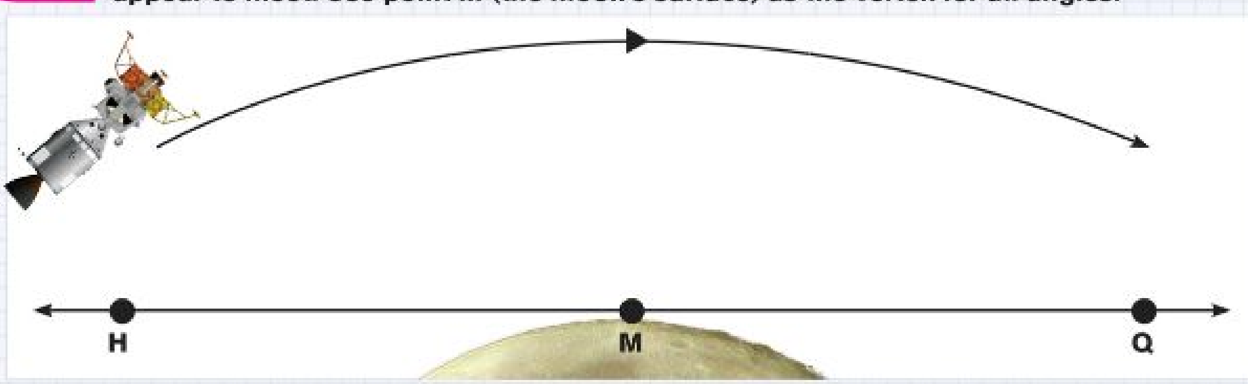
Step 3 Draw a ray to connect point *Y* to point *Z* to complete the angle:

Step 4 Name your angle using the points in the angle, with the vertex in the middle. This angle is ∠*XYZ*.



YOUR TURN

Complete the diagram of the moon lander's flight plan by drawing the angles that Johnson calculated. Line HMQ marks the horizon, or the line where the moon and sky appear to meet. Use point M (the moon's surface) as the vertex for all angles.



1 The moon lander traveled from left to right. When it was 35° above the moon's horizon line, it began its landing. Draw a ray with a point of *B* to create this angle. What's this angle's name?

2 Forty seconds later, the spacecraft began tilting toward the moon and had moved an additional 16° above the horizon. Draw a ray with point *C* to create a 16° angle above the angle you drew in No. 1. What is the name of this new angle?

3 Another 75 seconds later, the spacecraft was in position to detach the lander at 94° from the angle you drew in No. 2. Draw a ray with point *D* to make the angle and name it.

4 What is the measurement of ∠*DMQ* that you created? Explain how you determined this.