

NEXT ENGINEERS

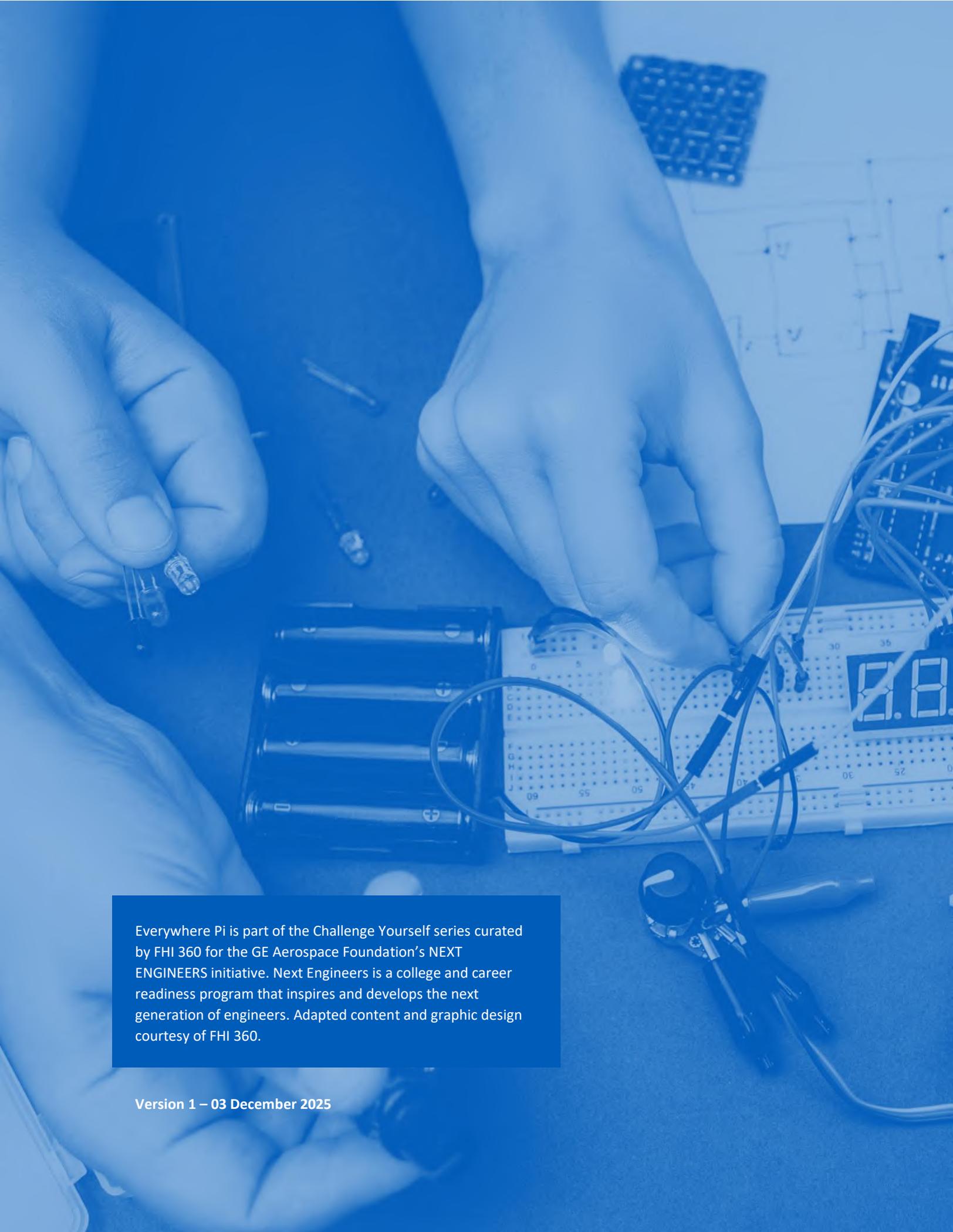


CHALLENGE YOURSELF

Pi Day:
Everywhere Pi
All Engineering



NEXT ENGINEERS



Everywhere Pi is part of the Challenge Yourself series curated by FHI 360 for the GE Aerospace Foundation's NEXT ENGINEERS initiative. Next Engineers is a college and career readiness program that inspires and develops the next generation of engineers. Adapted content and graphic design courtesy of FHI 360.

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Everywhere Pi

NERD OUT

Useful pi

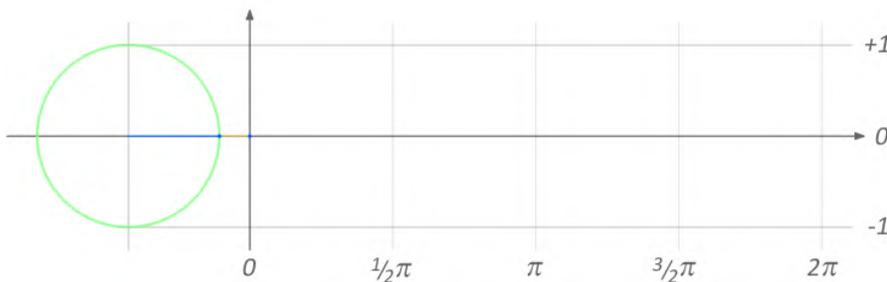
The famous mathematical constant pi (π) is famous for a reason. It is incredibly useful. It is needed anytime one deals with circles, cylinders, or spheres. This does not just include calculating areas and circumferences. It is also needed to calculate circular or angular velocities and accelerations (how quickly things spin and how quickly their rate of spin is changing).

In fact, π is needed when working with curves of many kinds, not just circles, which makes it indispensable to civil and mechanical engineers as well as architects.

Pi underpins the global positioning system (GPS) since the earth is close to a perfect sphere. Indeed, NASA scientists use π all the time when calculating rocket trajectories and orbits.

Electrical engineers rely on π to help them calculate the current and voltage in different electronic circuits containing inductors and capacitors.

Pi can be used to describe waves of all kinds, from those on a beach to light moving through space. It is also needed to describe the behavior of sub-atomic particles in quantum physics. Physicists at the Large Hadron Collider (LHC) use π all the time, not only because the collider is circular, but also because of the shape of the orbits of electrons and other sub-atomic particles.

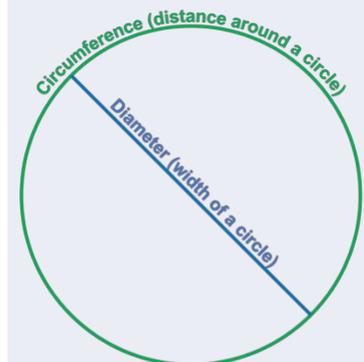


This animation shows the relationship between a unit circle and a simple wave
Sine curve drawing animation is released in the public domain
https://commons.wikimedia.org/wiki/File:Sine_curve_drawing_animation.gif



WHAT IS PI?

Pi (represented by the symbol π) is the ratio of the length of a circle's circumference to its diameter and has a value of approximately 3.14.



$$\pi = \frac{\text{Circumference}}{\text{Diameter}} \approx 3.14$$



Pi was also initially involved in the calculation of the acceleration due to gravity on earth and the definition of a meter. This involved devising a pendulum that completed a swing every two seconds. Because of this, it turns out that $g \approx \pi^2$.

PLANET Pi

π

$\pi = c/d$

ONE OF THE MOST WIDELY USED MATHEMATICAL CONSTANTS (THAT IS, A NUMBER THAT NEVER CHANGES), PI IS THE RATIO OF ANY CIRCLE'S CIRCUMFERENCE TO ITS DIAMETER. WHILE MOST SIMPLE CALCULATIONS REQUIRE JUST A FEW DIGITS OF PI (3.142 347), THE NUMBER ACTUALLY GOES ON FOREVER WITHOUT REPETITION OR PATTERN. DESPITE THAT, IT'S ACTUALLY VERY SIMPLE TO USE AND COMES IN HANDY AMONGST MANY FOR MATHS/PI. SCIENTISTS AND ENGINEERS STUDYING PLANETS IN OUR SOLAR SYSTEM AND EVEN WORLDS BEYOND! LEARN SOME WAYS THAT SCIENTISTS AND ENGINEERS USE PI, THEN PUT YOURSELF IN THEIR SHOES AND SEE JUST HOW MANY THINGS YOU CAN DISCOVER ABOUT PLANET PI. BELOW WITH JUST ITS CIRCUMFERENCE -- AND, OF COURSE, YOUR NEW FRIEND PI.

5 WAYS NASA USES PI

YOU'D BE SURPRISED HOW MUCH PI COMES UP AT NASA -- FROM SIMPLE USES LIKE CALCULATING THE AREA OF A CRATER TO APPLICATIONS AS COMPLEX AS CHANGING A SPACECRAFT'S ORBIT. BELOW ARE SOME WAYS SCIENTISTS AND ENGINEERS USE PI -- WHEN THEY'RE NOT EATING IT!

KEEPING SPACECRAFT CHUGGING ALONG

PROPULSION ENGINEERS USE PI ALL THE TIME IN LOGGING AT THE VOLUME AND SURFACE AREAS OF PROPELLANT TANKS. IT'S HOW THEY SIZE TANKS AND CALCULATE LIQUID PROPELLANT VOLUMES TO KEEP SPACECRAFT GOING AND GOING -- PI IS ALSO USED TO DETERMINE THE DIFFUSION RATE OF PROPELLANT VAPORS THROUGH PROPELLANT LINES.

GETTING NEW PERSPECTIVES ON SATURN

A TECHNIQUE CALLED A "PI TRANSFER" USES THE GRAVITY OF SATURN'S LARGEST MOON, TITAN, TO ALTER THE ORBIT OF THE CASSINI SPACECRAFT SO IT CAN GAIN DIFFERENT PERSPECTIVES ON SATURN AND ACHIEVE A WIDE VARIETY OF SCIENCE OBJECTIVES. DURING A PI TRANSFER, CASSINI FLIES BY TITAN AT OPPOSITE SIDES OF ITS ORBIT AROUND SATURN. I.E., TITAN'S ORBITAL POSITION DIFFERS BY PI RADIANS BETWEEN THE TWO FLIESBYS AND USES TITAN'S GRAVITY TO CHANGE ITS ORBITAL PERSPECTIVE ON THE RINGED PLANET.

LEARNING WHAT ASTEROIDS ARE MADE OF

AS TOUGH AS THEY SEEM, ASTEROIDS' INSIDES AREN'T TOO HARD TO CRACK. SINCE PI (AND THE ASTEROID'S RADIUS AND MASS), SCIENTISTS CAN EASILY CALCULATE THE DENSITY OF AN ASTEROID AND FIND OUT WHAT IT'S MADE OF: ICE, ROCK, NOW, ETC.

MEASURING CRATERS

KNOWING JUST THE CIRCUMFERENCE, DIAMETER AND SURFACE AREA OF A CRATER CAN TELL SCIENTISTS A LOT ABOUT THE ASTEROID OR METEOR THAT MAY HAVE CARVED IT OUT. THEY CAN EVEN HELP SCIENTISTS TRACE DOWN THE PARENT OF THE CRATER BOLIDE.

FINDING THE SIZE OF PLANETS OUTSIDE OUR SOLAR SYSTEM

SCIENTISTS USE PI IN THE SEARCH FOR EXOPLANETS. FIRST, THEY OBSERVE HOW MUCH THE LIGHT CURVE OF A PLANET'S PARENT STAR DECREASES WHEN THE ORBITING PLANET PASSES IN FRONT OF IT. BY COMBINING THE PERCENT OF THIS DECREASE WITH THE FORMULA FOR THE AREA OF A CIRCLE, IT'S POSSIBLE TO DEDUCE THE PLANET'S SIZE.

Pi CHALLENGE:

NOW IT'S TIME TO PUT YOURSELF TO THE TEST! USING ONLY THE CIRCUMFERENCE OF PLANET PI BELOW, CAN YOU FIND ITS DIAMETER, RADIUS, AREA, SURFACE AREA AND VOLUME? WHAT ELSE CAN YOU DISCOVER ABOUT PLANET PI? USE THE TOOLKIT OF PI BELOW TO GET STARTED!

CIRCUMFERENCE OF PLANET PI = 314,159 MILES

TOOLKIT OF PI - FORMULAS

CIRCUMFERENCE $C = \pi d$ <small>THE DISTANCE AROUND THE EDGE OF A CIRCLE</small>	RADIUS $R = C / 2\pi$ <small>THE DISTANCE FROM THE CENTER OF A CIRCLE TO ITS EDGE</small>	SURFACE AREA (SPHERE) $S = 4\pi r^2$ <small>THE TOTAL AREA OF THE SURFACE OF A 3-D OBJECT (SPHERE)</small>	VOLUME (SPHERE) $V = (4/3)\pi r^3$ <small>THE SPACE CONSUMED BY OR CAPACITY OF A 3-D OBJECT (SPHERE)</small>
DIAMETER $D = C / \pi$ <small>THE DISTANCE FROM ONE SIDE OF A CIRCLE TO THE OTHER</small>	AREA (CIRCLE) $A = \pi r^2$ <small>THE SIZE OF A SURFACE (CIRCLE)</small>		

Five ways NASA uses Pi is used under fair use
<https://www.universetoday.com/wp-content/uploads/2014/03/11011.jpg>

Playful pi

But π can also be quite playful. It turns up in other less serious but no less surprising ways. Watch the following videos to learn more.



- *A Surprising Pi and 5* (2:36)
https://www.youtube.com/watch?v=IMY2_yzDm9I
This video explores how the number 5 and π are related.
- *Pi hiding in prime regularities* (29:42)
https://www.youtube.com/watch?v=NaL_Cb42WyY
This is a long and fairly technical video that explores how π turns up in the distribution of prime numbers.
- *The most unexpected answer to a counting puzzle* (5:12)
<https://www.youtube.com/watch?v=HEfHFsfGXjs>
This video describes how π turns up in the number of times two sliding blocks collide with each other on a perfect frictionless surface.
- *Why do colliding blocks compute pi?* (15:12)
<https://www.youtube.com/watch?v=jsYwFizhncE>
This video solves the sliding block problem introduced in the video above.
- *Why is pi here? And why is it squared? A geometric answer to the Basel problem* (19:03)
<https://www.youtube.com/watch?v=d-o3eB9sfls>
Euler proved that the infinite sum $1 + \frac{1}{4} + \frac{1}{9} + \frac{1}{16} + \frac{1}{25} + \dots = \frac{\pi^2}{6}$. This video provides a reasonably easy to understand geometric answer to why this is the case.

Surprising pi

What other specific or surprising uses of π can you find? Do some research and share what you find at **#NextEngineersDIY**.

