

# SYSTEM ALERT!

Tomorrow is almost here.

## Our computer ancestry

In the 18th century, a ship lost at sea had no way to call for help. With no land in sight, pilots of naval and shipping vessels relied on the Moon, planets, and stars to navigate.

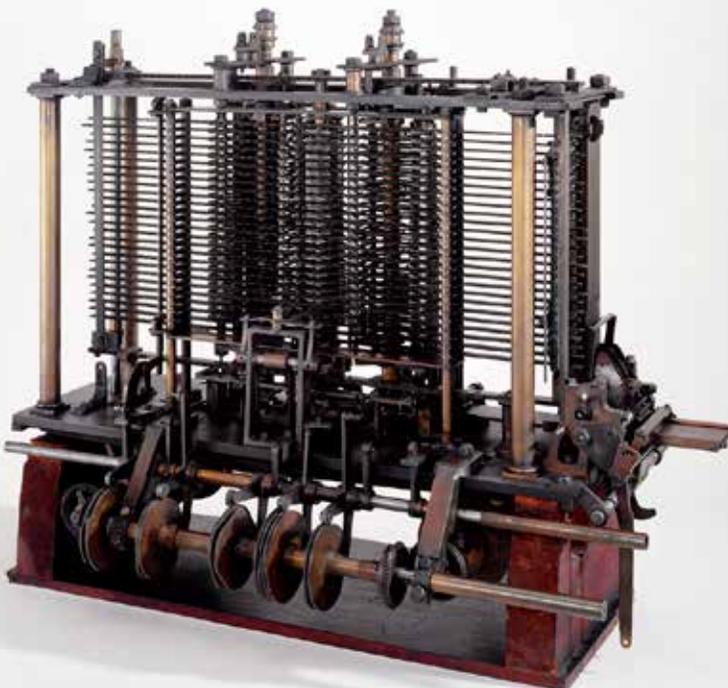
In 1767, the British government published the *Nautical Almanac* to help sailors find their path by studying the night skies. The book's mathematical tables were created in government offices with the help of computers. The computers spent months calculating the astronomical data and no doubt saved lives and money.

If that time line sounds off to you, know this: for hundreds of years the word computer did not mean a machine. It meant a person who did math. These human computers did valuable work for business, military, and science. ⚠️

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- *Electric Tech STEM Expedition*®
- *Mechanical Makers Career Expedition*
- *Taking Control STEM Expedition*



Think a computer must be electronic? Think again. Some early computers were constructed of mechanical parts such as metal gears.

## A DREAM BEFORE ITS TIME

People have long been amazed at math's ability to describe and predict nature. The ancient philosopher Pythagoras even believed "All things are number." This same idea tugged at inventor Charles Babbage in the 1800s.

Babbage daydreamed of a machine that could solve math equations and solve real-world problems. In 1837, he imagined the Analytical Engine. If built, it would have been a programmable computer that relied on gears and metal rods instead of electric circuits.

Babbage was inspired by mechanical weaving looms used in textile factories. The looms used paper cards with punched holes to control the motion of thread. Babbage believed the cards could be used to program the operation of his own machine. Ada Lovelace once said, "The Analytical Engine weaves algebraic patterns, just as the Jacquard loom weaves flowers and leaves."

The British government attempted to build a simplified version. But the metalworking of the era was not up to the task. How could history have unfolded differently if the Analytical Engine had been built? ⚠️

# TALKING TO AN UNBUILT MACHINE

Without a purpose, a computing machine is just a useless curiosity. Programmers use code to give computers instructions to define their purpose. Mathematician Ada Lovelace was the world's first computer programmer. She worked with inventor Charles Babbage and pioneered techniques for programming the computer he designed.

She even foresaw that computers could be used to play music. She also invented the concept of looping – causing the computer to perform the same task over and over for a specified time. Lovelace believed there was a connection between math and imagination. Both reveal secrets about the world. ⚠️

Ada Lovelace was the daughter of the poet Lord Byron. As a child, she had a great curiosity and was obsessed with the possibility of creating a machine that could fly.



## UNSUNG HEROES

During World War II, American men were fighting on the front lines. The military hired teams of women to code and operate computers. It was not until the 1980s that computer programming came to be seen as a male-oriented career. Companies are once again actively looking to recruit females into their ranks of coders. ⚠️

# WHEN CODEBREAKING SAVED THE WORLD

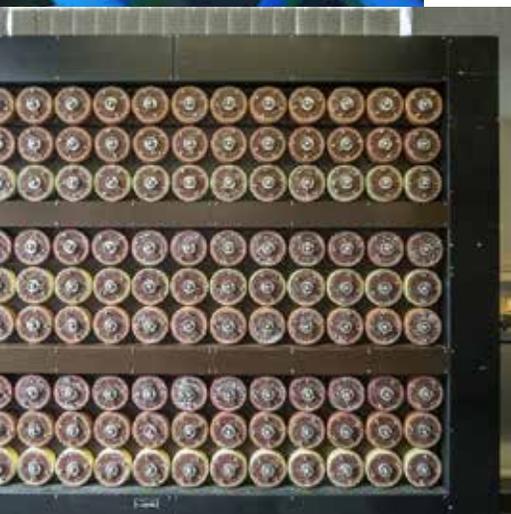


In 1941, the world was at war. Allied forces had intercepted Nazi military messages but could not understand them. They were written in a secret code the Nazis believed was unbreakable.

Enter Alan Turing, a British mathematician obsessed with the idea of creating machines that could think.

Turing led a team that perfected a computing machine called the bombe (not to be confused with a bomb!). This machine was made of both mechanical and electrical components. Through a logical process, it was able to reverse the encryption used by the Nazis. This ability gave the Allied forces a great advantage and brought the war in Europe to a quicker end. Some believe Turing's contribution saved 14 million lives.

The bombe was not the all-purpose thinking machine Turing dreamed of. Decryption was its only use. Still, the bombe demonstrated that investing in computing machines could lead to huge military advantages. This attitude change led to many developments. ⚠️



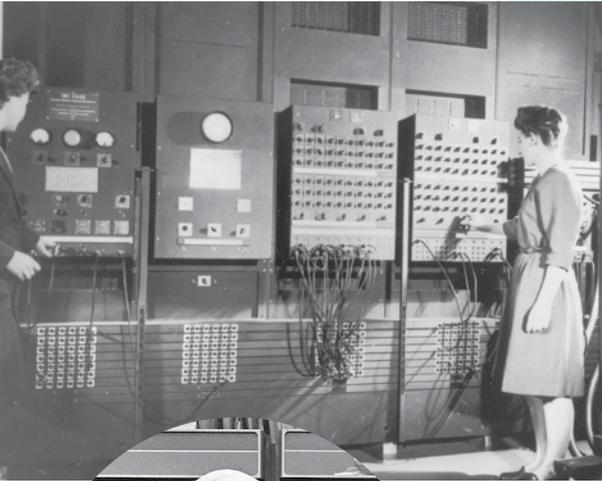
The rotating drums of the bombe machine helped the British decode messages sent by the Nazis. The Nazis altered their code every midnight, so the bombe was in constant use.

# FIRST STEP IN THE MODERN AGE

World War II led to a global arms race that produced the atomic bomb and, later, the more powerful hydrogen bomb. The debate rages about whether these weapons have done more to take lives or more to save them. It is not pleasant to know that the first general-purpose computer helped create the hydrogen bomb, but it is true.

ENIAC – the Electronic Numerical Integrator and Computer – came online in 1945. A gifted mathematician named John von Neumann modified it to make it programmable and then wrote programs that turned ENIAC into a tool for designing the hydrogen bomb.

ENIAC was not only the first general-purpose electronic computer, but it was also the first reprogrammable computer. It was far faster than mechanical calculating machines. Compared to today's computers, however, it was a dinosaur. It weighed in at 27 tons and required repairs more than once a week. ⚠️



Grace Hopper – they called her Grandma COBOL after the programming language she helped pioneer.

## IN ENGLISH, PLEASE

The math-based computer code imagined by Ada Lovelace used holes in paper cards. In the 1950s, Navy Rear Admiral Grace Hopper had a more user-friendly idea: why not code using plain English? Her employers were skeptical, so in her spare time she created the first compiler. It translated the machine logic of traditional code into terms familiar to humans. Programmers all over the world were amazed at how this improved their coding ability. Hopper worked on ENIAC as well as other early computers. She was known as an extremely hard worker with a good sense of humor. ⚠️

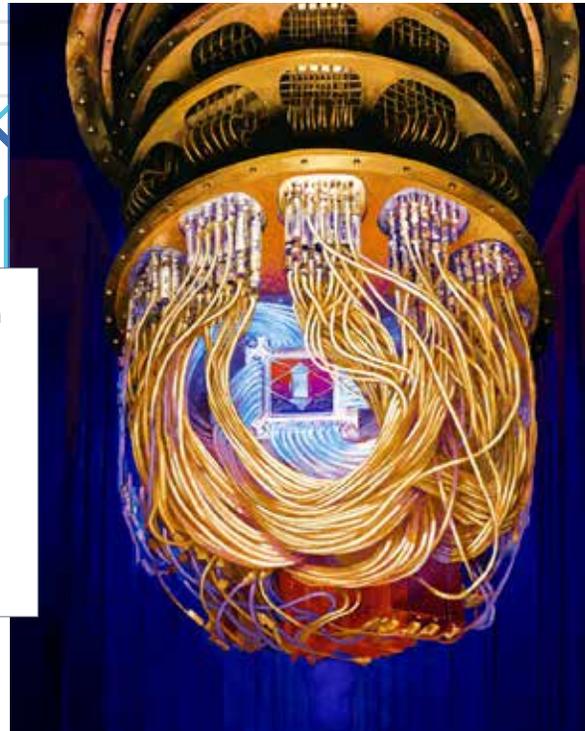
# Computing enters the era of the weird

The tag line of *SySTEM Alert!* is “Tomorrow is almost here.” That has never been truer than right now.

Recently Google announced it has achieved “quantum supremacy.” What in the world is a quantum, and why does Google think it is so great? Simply put, quantum mechanics is the science of the very small. When scientists speak of a quantum, they refer to the smallest possible piece of something.

Computer scientists at Google used what we know about these tiny scales to create a new type of computer with amazing capabilities. They call this quantum computer Sycamore. They gave Sycamore a challenge: analyze a set of random numbers. The Google scientists estimated it would take the world's greatest non-quantum supercomputer 10,000 years to do the calculation. It took Sycamore 200 seconds.

Are quantum computers the next era in computing? If so, we might have just entered the next era!



## A SHORT LESSON ON THE VERY SMALL

An electron is the smallest unit – or quantum – of electrical charge. You might have heard that traditional computers think in ones and zeroes. In most computer processors, electron movement is controlled by tiny switches that turn this flow of electricity on or off. The off state is represented by zero. The on state is represented one.

Inside a quantum computer, a single electron can be in more than one place at the same time. Scientists call this a superposition of one and zero – both on and off. This flexibility is what gives quantum computers their power.

Just because we now know how to create a quantum computer, that doesn't mean we truly understand how an electron can be in two states at once. Physicist Richard Feynman once said that "If you think you understand quantum mechanics, you don't understand quantum mechanics."

## THE HISTORY OF THE FUTURE

Quantum computers have been on scientists' to-do list since the 1980s, but it has been hard to make one work reliably. Traditional computers like your laptop are fragile. But the inner workings of quantum computers are extremely fragile. Any interaction at all with the outside world, even stray air molecules moving around, cause their delicate precision to collapse.

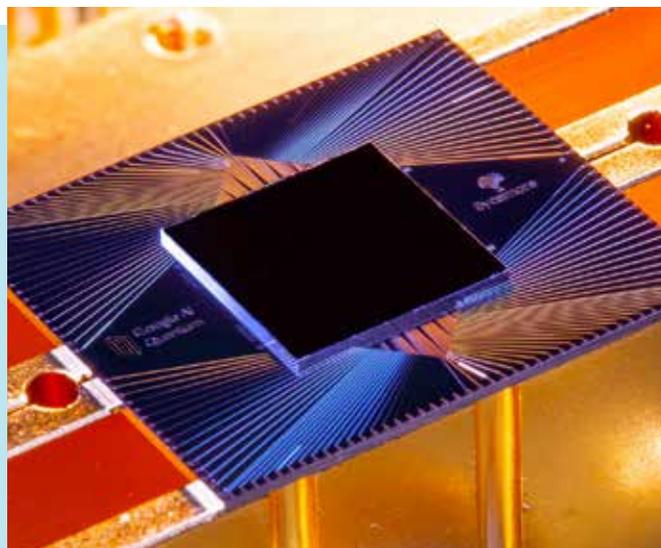
At high temperatures, molecules move more. So, what temperatures do you think quantum computers prefer? If you guessed extremely cold, you are right. The processor inside a quantum computer must be kept at temperatures near absolute zero. (Absolute zero is  $-459.67^{\circ}\text{F}$ .)

Programming languages to program quantum computers are being created now. Several are being developed open-source, which means programmers from all over the world can share them and even contribute to their creation.

Right now, quantum programmer still seems like an exotic career. But more quantum computers are being built, and they will play a big role in our future technology landscape. This future will need programmers. ⚠️

# JUST HOW SMALL ARE WE TALKING?

A speck of dust seems tiny, but compared to the scales that quantum physicists study, dust is enormous. In a single speck of dust there are quadrillions of atoms. (One quadrillion = 1,000,000,000,000,000.) And every one of those atoms is gigantic compared to quantum scales! ⚠️



Sycamore's processor allows a single particle to spin in two opposite directions at the same time. If you're confused, that's OK. Scientists are too.



## CODE CUBE

Get ready for code you can wear. Code Cube lets you create animations and soundscapes that respond to your movement. And the best part – you program it yourself! Using easy-to-learn block-based programming, the LED screen, accelerometer (motion sensor), and sound output features will be your artistic canvas. ⚠️



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Student name: \_\_\_\_\_ Class/Hour: \_\_\_\_\_

## **SySTEM Alert! Quiz (Volume 8, Number 2)**

1. To a traditional computer, one means \_\_\_\_\_ and zero means \_\_\_\_\_.
  - A. on, off
  - B. up, down
  - C. plus, minus
  - D. right, left
  
2. How many atoms are in a single speck of dust?
  - A. thousands
  - B. millions
  - C. billions
  - D. quadrillions
  
3. What temperatures do quantum computers prefer?
  - A. room temperature (about 70°F)
  - B. Arctic temperatures (about -50°F)
  - C. near absolute zero (-459.67°F)
  - D. solar surface temperatures (about 10,000°F)
  
4. Instead of electrical circuits, the Analytical Engine's design relied on \_\_\_\_\_.
  - A. gears and metal rods
  - B. liquid mercury
  - C. rotating drums
  - D. quantum supremacy
  
5. Who is credited as the world's first computer programmer?
  - A. Alan Turing
  - B. Ada Lovelace
  - C. Charles Babbage
  - D. Grace Hopper
  
6. The bombe was a computing machine used to decode messages sent by the Nazis during World War II. Some believe it saved 14 million \_\_\_\_\_.
  - A. American dollars
  - B. lives
  - C. British pounds
  - D. hours of translation time



7. Who created the first compiler, a system for turning human language into machine logic?
  - A. Alan Turing
  - B. Ada Lovelace
  - C. Grace Hopper
  - D. John von Neumann
  
8. What was the first task that the ENIAC computer was programmed to do in 1945?
  - A. calculate ocean navigation routes
  - B. play chess
  - C. help design the hydrogen bomb
  - D. count punch cards
  
9. How much did ENIAC weigh?
  - A. 3 pounds
  - B. 50 pounds
  - C. 5,000 pounds
  - D. 27 tons
  
10. What is quantum mechanics?
  - A. the science of the very small
  - B. the science of electrons
  - C. a way of arranging gears and metal rods
  - D. the hidden power of a Code Cube device

**Bonus:** Why do you think math is so useful for solving problems in the world?