# Grace Hopper

**Grace Brewster Murray Hopper** (née **Murray**; December 9, 1906 – January 1, 1992) was an American computer scientist and United States Navy rear admiral.[1] One of the first programmers of the Harvard Mark I computer, she was a pioneer of computer programming, inventing the first compiler for any computer programming language. She popularized the idea of machine-independent programming languages, which led to the development of COBOL, one of the first high-level programming languages.

Hopper had tried to enlist in the Navy during World War II. She had to join the Navy Reserves because she was too old to enlist at the age of 34. Hopper started her computing career working in the Harvard Mark I team led by Howard H. Aiken. In 1949, she joined the Eckert–Mauchly Computer Corporation, joining the team that developed the UNIVAC I in 1944. It was at Eckert–Mauchly that she began developing the compiler. She believed that computer code could be written in English using a programming language based on English words. The compiler would convert that code into machine code understood by computers. By 1952, Hopper finished her compiler, which was written for the A-0 System programming language.[2][3][4][5]

In 1954, Eckert–Mauchly chose Hopper to lead their department for automatic programming, and she led the release of some of the first compiled languages like FLOW-MATIC. In 1959, she participated in the CODASYL consortium, which consulted Hopper to guide them in creating a machine-independent programming language. This led to the COBOL language, inspired by her idea of a language being based on English. In 1966, she retired from the Naval Reserve, but in 1967, the Navy recalled her into active duty. In the Navy, she launched programs that helped standardize COBOL as well as newer languages like Fortran. She retired from the Navy in 1986 and found work as a consultant for the Digital Equipment Corporation, sharing her computing experiences.

Owing to her accomplishments and her naval rank, she was sometimes referred to as "Amazing Grace".[6][7] The U.S. Navy *Arleigh Burke*-class guided-missile destroyer USS *Hopper* was named for her, as was the Cray XE6 "Hopper" supercomputer at NERSC.[8] During her lifetime, Hopper was awarded 40 honorary degrees from universities across the world. In 1991, she received the National Medal of Technology. On November 22, 2016, she was posthumously awarded the Presidential Medal of Freedom by President Barack Obama.[9]

## Grace Murray Hopper



Rear Admiral Grace M. Hopper, 1984

| | |
|---|---|
| **Nickname(s)** | "Amazing Grace" |
| **Born** | December 9, 1906<br>New York City, New York, U.S. |
| **Died** | January 1, 1992 (aged 85)<br>Arlington, Virginia, U.S. |
| **Place of burial** | Arlington National Cemetery |
| **Allegiance** | United States of America |
| **Service/branch** | United States Navy |
| **Years of service** | 1943–1966, 1967–1971, 1972–1986 |
| **Rank** | Rear admiral (lower half) |
| **Awards** | Defense Distinguished Service Medal<br>Legion of Merit<br>Meritorious Service Medal<br>American Campaign Medal<br>World War II Victory Medal<br>National Defense Service Medal<br>Armed Forces Reserve Medal with two Hourglass Devices<br>Naval Reserve Medal<br>Presidential Medal of Freedom (posthumous) |

# Contents

# Early life and education

Hopper was born in New York City. She was the eldest of three children. Her parents, Walter Fletcher Murray and Mary Campbell Van Horne, were of Scottish and Dutch descent, and attended West End Collegiate Church.[10] Her great-grandfather, Alexander Wilson Russell, an admiral in the US Navy, fought in the Battle of Mobile Bay during the Civil War.



Grace Hopper (As Told By U.S. Chief Technology Officer Megan Smith)

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Grace was very curious as a child; this was a lifelong trait. At the age of seven, she decided to determine how an alarm clock worked, and dismantled seven alarm clocks before her mother realized what she was doing (she was then limited to one clock).[11] For her preparatory school education, she attended the Hartridge School in Plainfield, New Jersey. Hopper was initially rejected for early admission to Vassar College at age 16 (her test scores in Latin were too low), but she was admitted the following year. She graduated Phi Beta Kappa from Vassar in 1928 with a bachelor's degree in mathematics and physics and earned her master's degree at Yale University in 1930.

In 1934, she earned a Ph.D. in mathematics from Yale[12] under the direction of Øystein Ore.[13][14] Her dissertation, *New Types of Irreducibility Criteria*, was published that same year.[15] Hopper began teaching mathematics at Vassar in 1931, and was promoted to associate professor in 1941.[16]

She was married to New York University professor Vincent Foster Hopper (1906–76) from 1930 until their divorce in 1945.[13][17] She did not marry again, but chose to retain his surname.
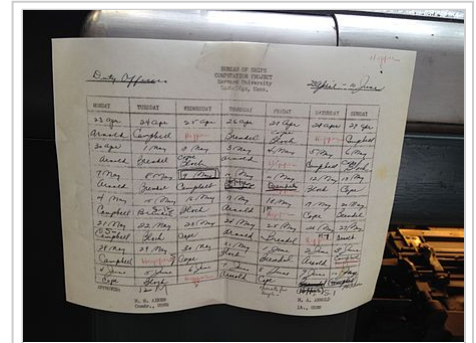
# Career

## World War II

Hopper had tried to enlist in the Navy early in the war. She was at age 34, too old to enlist, and her weight to height ratio was too low. She was also denied on the basis that her job as a mathematician and mathematics professor at Vassar College was valuable to the war effort.[18] During World War II in 1943, Hopper obtained a leave of absence from Vassar and was sworn into the United States Navy Reserve, one of many women to volunteer to serve in the WAVES. She had to get an exemption to enlist; she was 15 pounds (6.8 kg) below the Navy minimum weight of 120 pounds (54 kg). She reported in December and trained at the Naval Reserve Midshipmen's School at Smith College in Northampton, Massachusetts. Hopper graduated first in her class in 1944, and was assigned to the Bureau of Ships Computation Project at Harvard University as a lieutenant, junior grade. She served on the Mark I computer programming staff headed by Howard H. Aiken. Hopper and Aiken co-authored three papers on the Mark I, also known as the Automatic Sequence Controlled Calculator. Hopper's request to transfer to the regular Navy at the end of the war was declined due to her advanced age of 38. She continued to serve in the Navy Reserve. Hopper remained at the Harvard Computation Lab until 1949, turning down a full professorship at Vassar in favor of working as a research fellow under a Navy contract at Harvard.[19]



Hopper's signatures on a duty officer signup sheet for the Bureau of Ships Computation Project at Harvard, which built and operated the Mark I

## UNIVAC

In 1949, Hopper became an employee of the Eckert–Mauchly Computer Corporation as a senior mathematician and joined the team developing the UNIVAC I.[16] When she recommended that a new programming language be developed using entirely English words, she "was told very quickly that [she] couldn't do this because computers didn't understand English." This idea was not accepted for 3 years, and she published her first paper on the subject, compilers, in 1952. In the early 1950s, the company was taken over by the Remington Rand corporation, and it was while she was working for them that her original compiler work was done. The compiler was known as the A compiler and its first version was A-0.[20]:11

In 1952 she had an operational compiler. She later said that "Nobody believed that," and that she "had a running compiler and nobody would touch it. They told me computers could only do arithmetic."[21] She goes on to say that her compiler "translated mathematical notation into machine code. Manipulating symbols was fine for mathematicians but it was no good for data processors who were not symbol manipulators. Very few people are really symbol manipulators. If they are they become professional mathematicians, not data processors. It's much easier for most people to write an English statement than it is to use symbols. So I decided data processors ought to be able to write their programs in English, and the computers would translate them into machine code. That was the beginning of COBOL, a computer language for data processors. I could say "Subtract income tax from pay" instead of trying to write that in octal code or using all kinds of symbols. COBOL is the major language used today in data processing."[22]"
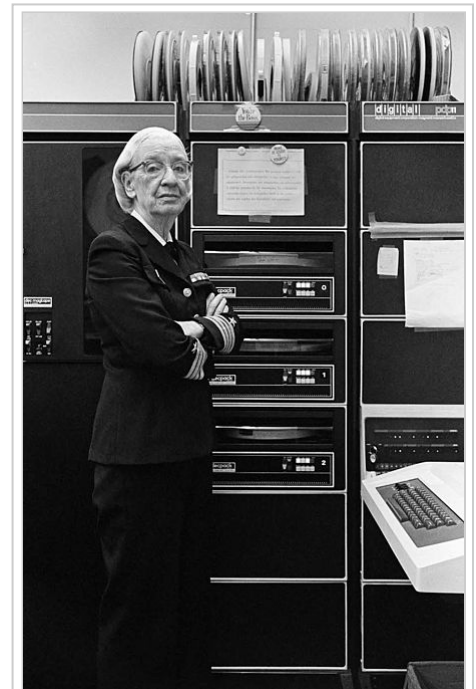


Grace Murray Hopper, in her office in Washington DC, 1978, ©Lynn Gilbert

In 1954 Hopper was named the company's first director of automatic programming, and her department released some of the first compiler-based programming languages, including MATH-MATIC and FLOW-MATIC.[16]

## COBOL

In the spring of 1959, computer experts from industry and government were brought together in a two-day conference known as the Conference on Data Systems Languages (CODASYL). Hopper served as a technical consultant to the committee, and many of her former employees served on the short-term committee that defined the new language COBOL (an acronym for **CO**mmon **B**usiness-**O**riented **L**anguage). The new language extended Hopper's FLOW-MATIC language with some ideas from the IBM equivalent, COMTRAN. Hopper's belief that programs should be written in a language that was close to English (rather than in machine code or in languages close to machine code, such as assembly languages) was captured in the new business language, and COBOL went on to be the most ubiquitous business language to date.[23]



Hopper at the UNIVAC I console, c. 1960

From 1967 to 1977, Hopper served as the director of the Navy Programming Languages Group in the Navy's Office of Information Systems Planning and was promoted to the rank of captain in 1973.[19] She developed validation software for COBOL and its compiler as part of a COBOL standardization program for the entire Navy.[19]

### Standards

In the 1970s, Hopper advocated for the Defense Department to replace large, centralized systems with networks of small, distributed computers. Any user on any computer node could access common databases located on the network.[20]:119 She developed the implementation of standards for testing computer systems and components, most significantly for early programming languages such as FORTRAN and COBOL. The Navy tests for conformance to these standards led to significant convergence among the programming language dialects of the major computer vendors. In the 1980s, these tests (and their official administration) were assumed by the National Bureau of Standards (NBS), known today as the National Institute of Standards and Technology (NIST).

# Retirement



Hopper being promoted to the rank of commodore in 1983

In accordance with Navy attrition regulations, Hopper retired from the Naval Reserve with the rank of commander at age 60 at the end of 1966.[24] She was recalled to active duty in August 1967 for a six-month period that turned into an indefinite assignment. She again retired in 1971, but was again asked to return to active duty in 1972. She was promoted to captain in 1973 by Admiral Elmo R. Zumwalt, Jr.[25]

After Republican Representative Philip Crane saw her on a March 1983 segment of *60 Minutes*, he championed H.J.Res. 341 (https://www.congress.gov/bill/98th-congress/house-joint-resolution/341), a joint resolution originating in the House of Representatives, which led to her promotion to commodore (admiral, O-7) by special Presidential appointment.[25][26][27][28] She remained on active duty for

several years beyond mandatory retirement by special approval of Congress.[29] Effective November 8, 1985, the rank of commodore was renamed rear admiral (lower half) and Hopper became one of the Navy's few female admirals.

Admiral Hopper retired (involuntarily) from the Navy on August 14, 1986 after a career over 42 years. At a celebration held in Boston on the USS *Constitution* to commemorate her retirement, Hopper was awarded the Defense Distinguished Service Medal, the highest non-combat decoration awarded by the Department of Defense.

At the time of her retirement, she was the oldest active-duty commissioned officer in the United States Navy (79 years, eight months and five days), and aboard the oldest commissioned ship in the United States Navy (188 years, nine months and 23 days).[30] (Admirals William D. Leahy, Chester W. Nimitz, Hyman G. Rickover and Charles Stewart were the only other officers in the Navy's history to serve on active duty at a higher age. Leahy and Nimitz served on active duty for life due to their promotions to the rank of fleet admiral.)

# Post retirement

Following her retirement from the Navy she was hired as a senior consultant to Digital Equipment Corporation (DEC), a position she retained until her death in 1992, aged 85.

Her primary activity in this capacity was as a goodwill ambassador, lecturing widely on the early days of computers, her career, and on efforts that computer vendors could take to make life easier for their users. She visited most of Digital's engineering facilities, where she generally received a standing ovation at the conclusion of her remarks.

She often recounted that during her service she was frequently asked by admirals and generals why satellite communication would take so long. So during many of her lectures, she illustrated a nanosecond using salvaged obsolete Bell System 25 pair telephone cable, cut it to 11.8 inch (30 cm) lengths, the distance that light travels in one nanosecond, and handed out the individual wires to her listeners. Although no longer a serving officer, she always wore her Navy full dress uniform to these lectures, which is allowed by US Navy uniform regulations.

> The most important thing I've accomplished, other than building the compiler, is training young people. They come to me, you know, and say, 'Do you think we can do this?' I say, "Try it." And I back 'em up. They need that. I keep track of them as they get older and I stir 'em up at intervals so they don't forget to take chances.[31]

# Death

Hopper died in her sleep of natural causes on New Year's Day 1992 at her home in Arlington, Virginia; she was 85 years of age. She was interred with full military honors in Arlington National Cemetery.[32]

# Dates of rank

- Ensign - December 1943
- Lieutenant (junior grade) - June 27, 1944
- Lieutenant - January 1, 1946
- Lieutenant Commander - April 1, 1952
- Commander - July 1, 1957
- Retired - December 31, 1966

- Recalled to active duty - August 1967
- Retired - 1971
- Recalled to active duty - 1972
- Captain - August 2, 1973
- Commodore - December 15, 1983
- Rear Admiral (Lower Half) - November 8, 1985
- Final retirement - August 31, 1986

# Awards and honors

## Military awards

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|---|---|---|---|
| **Top Row** | Defense Distinguished Service Medal (1986) | Legion of Merit (1967) | Meritorious Service Medal (1980) |
| **2nd Row** | Presidential Medal of Freedom (2016, Posthumous) | American Campaign Medal (1944) | World War II Victory Medal (1945) |
| **Bottom Row** | National Defense Service Medal with bronze service star (1953, 1966) | Armed Forces Reserve Medal with two bronze hourglasses (1963, 1973, 1993) | Naval Reserve Medal (1953) |

## Other awards

- 1964: Hopper was awarded the Society of Women Engineers Achievement Award, the Society's highest honor, "In recognition of her significant contributions to the burgeoning computer industry as an engineering manager and originator of automatic programming systems.".[33]
- 1969: Hopper was awarded the inaugural Data Processing Management Association Man of the Year award (now called the Distinguished Information Sciences Award).[34]
- 1971: The annual Grace Murray Hopper Award for Outstanding Young Computer Professionals was established in 1971 by the Association for Computing Machinery.
- 1973: First American and the first woman of any nationality to be made a Distinguished Fellow of the British Computer Society.
- 1982: American Association of University Women Achievement Award and an Honorary Doctor of Science from Marquette University.[35]
- 1985: Honorary Doctor of Letters from Western New England College (now Western New England University).[36][37]
- 1986: Upon her retirement, she received the Defense Distinguished Service Medal.
- 1987: The first Computer History Museum Fellow Award Recipient "for contributions to the development of programming languages, for standardization efforts, and for lifelong naval service."[38]
- 1988: Golden Gavel Award at the Toastmasters International convention in Washington, DC.
- 1991: National Medal of Technology.
- 1991: Elected a Fellow of the American Academy of Arts and Sciences.[39]
- 1996: USS *Hopper* (DDG-70) was launched. Nicknamed *Amazing Grace*, it is on a very short list of U.S. military vessels named after women.

- 2001: Eavan Boland wrote a poem dedicated to Grace Hopper titled "Code" in her 2001 release *Against Love Poetry*.
- 2001: The Gracies, the Government Technology Leadership Award were named in her honor.[40]
- 2009: The Department of Energy's National Energy Research Scientific Computing Center named its flagship system "Hopper".[41]
- 2009: Office of Naval Intelligence creates the Grace Hopper Information Services Center.[42]
- 2013: Google made the Google Doodle for Hopper's 107th birthday an animation of her sitting at a computer, using COBOL to print out her age. At the end of the animation, a moth flies out of the computer.[43][44]
- 2016: On November 22, 2016 Hopper was posthumously awarded a Presidential Medal of Freedom for her accomplishments in the field of computer science.[45]

# Legacy

- On February 11, 2017 Yale University announced its intent to rename Calhoun College, one of its twelve undergraduate residential colleges, after Hopper following years of controversy about its previous namesake John C. Calhoun. Hopper was a graduate of Yale University, receiving an M.A. in 1930 and a Ph.D in 1934.
- **The Grace Hopper Celebration of Women in Computing** is a convention for Women in the field of Computer Science and Technology. It is named after Hopper to honor her for her work and influence in the field of computing, and her push for more women to enter and stay in the tech field. It features a wide array of educational and professional development courses and workshops, including a lesson on compilers, which Hopper invented and pioneered, and a career fair, in order to help connect women in the computing field with potential employers.
- The Navy's Fleet Numerical Meteorology and Oceanography Center is located at 7 Grace Hopper Avenue in Monterey, California; the National Weather Service's San Francisco / Monterey Bay Area Hydrology / Geomorphology office is at 21 Grace Hopper Avenue.
- Grace M. Hopper Navy Regional Data Automation Center at Naval Air Station, North Island, California.
- *Grace Murray Hopper Park*, located on South Joyce Street in Arlington, Virginia, is a small memorial park in front of her former residence (River House Apartments) and is now owned by Arlington County, Virginia.
- Women at Microsoft Corporation formed an employee group called Hoppers and established a scholarship in her honor. Hoppers has over 3000 members worldwide.
- Brewster Academy, a school located in Wolfeboro, New Hampshire, United States, dedicated their computer lab to her in 1985, calling it the Grace Murray Hopper Center for Computer Learning.[25] The academy bestows a Grace Murray Hopper Prize to a graduate who excelled in the field of computer systems.[46] Hopper had spent her childhood summers at a family home in Wolfeboro.
- An administration building on Naval Support Activity Annapolis (previously known as Naval Station Annapolis) in Annapolis, Maryland is named the Grace Hopper Building in her honor.[25]
- Vice Admiral Walter E. "Ted" Carter announced on 8 September 2016 at the Athena Conference that the Naval Academy's newest Cyber Operations building would be named Hopper Hall after Admiral Grace Hopper. This is the first building at any service academy named after a woman. In his words, "Grace Hopper was the admiral of the Cyber Seas."
- The US Naval Academy also owns a Cray XC-30 supercomputer named "Grace," hosted at the University of Maryland-College Park.[47]
- Building 1482 aboard Naval Air Station North Island, housing the Naval Computer and Telecommunication Station San Diego, is named the Grace Hopper Building.
- Building 6007, C2/CNT West, Command, control, communications, computers, intelligence, surveillance and reconnaissance, or C4ISR, Center of Excellence in Aberdeen Proving Ground, Maryland is named the Rear Admiral Grace Hopper Building.
- A named professorship in the Department of Computer Sciences was established at Yale University in her honor. Joan Feigenbaum was named to this chair in 2008.[48]
- Grace Hopper's legacy was an inspiring factor in the creation of the Grace Hopper Celebration of Women in Computing.[49] Held yearly, this conference is designed to bring the research and career interests of women

in computing to the forefront.

- Grace Hopper Academy is a for-profit immersive programming school in New York City named in Grace Hopper's honor. It opened in January 2016 with the goal of increasing the proportion of women in software engineering careers.[50][51]
- A bridge over Goose Creek joining the north and south sides of the Naval Support Activity Charleston side of Joint Base Charleston, South Carolina is named the Grace Hopper Memorial Bridge in her honor.[52]
- Grace Hopper was awarded 40 honorary degrees from universities worldwide during her lifetime.[53][54][55]
- Beginning in 2015, one of the nine competition fields at the FIRST Robotics Competition world championship is named for Hopper.[56]
- *Born with Curiosity: The Grace Hopper Story* is an upcoming documentary film.[57]

# Anecdotes

Throughout much of her later career, Hopper was much in demand as a speaker at various computer-related events. She was well known for her lively and irreverent speaking style, as well as a rich treasury of early war stories. She also received the nickname "Grandma COBOL".



Photo of "first computer bug"

- While she was working on a Mark II Computer at a US Navy research lab in Dahlgren, Virginia in 1947, her associates discovered a moth stuck in a relay impeding its operation. While neither Hopper nor her crew mentioned the phrase "debugging" in their logs, the case was held as an instance of literal "debugging." The term *bug* had been in use for many years in engineering.[58][59] The remains of the moth can be found in the group's log book at the Smithsonian Institution's National Museum of American History in Washington, D.C.[60]
- Grace Hopper is famous for her *nanoseconds* visual aid. People (such as generals and admirals) used to ask her why satellite communication took so long. She started handing out pieces of wire that were just under one foot long (11.80 inches)—the distance that light travels in one nanosecond. She gave these pieces of wire the metonym "nanoseconds."[28] She was careful to tell her audience that the length of her nanoseconds was actually the maximum speed the signals would travel in a vacuum, and that signals would travel more slowly through the actual wires that were her teaching aids. Later she used the same pieces of wire to illustrate why computers had to be small to be fast. At many of her talks and visits, she handed out "nanoseconds" to everyone in the audience, contrasting them with a coil of wire 984 feet long,[61] representing a microsecond. Later, while giving these lectures while working for DEC, she passed out packets of pepper, calling the individual grains of ground pepper picoseconds.

Jay Elliot described Grace Hopper as appearing to be "'all Navy', but when you reach inside, you find a 'Pirate' dying to be released".[62]

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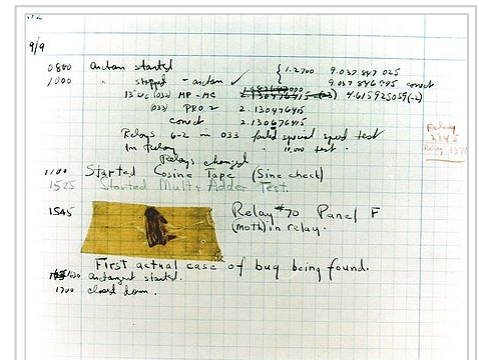- Weiss, Eric A. (*IEEE Annals of the History of Computing* 14: 56–58, 1992)

# See also

- Grace Hopper Celebration of Women in Computing
- Women in computing
- Women in the United States Navy
- Systems engineering
- *Code: Debugging the Gender Gap*
- List of pioneers in computer science

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# External links

- RADM Grace Hopper, USN Ret. (https://web.archive.org/web/20100224101438/http://www.chips.navy.mil/links/grace_hopper/womn.htm) at the Wayback Machine (archived February 24, 2010) from *Chips*, the United States Navy information technology magazine.
- *Grace Hopper: Navy to the Core, a Pirate at Heart* (http://usnhistory.navylive.dodlive.mil/2014/12/09/grace-hopper-navy-to-the-core-a-pir

Wikimedia Commons has media related to *Grace Hopper*.

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ate-at-heart/) (2014),To learn more about Hopper's story and Navy legacy navy.mil.
- *The Queen of Code* (http://fivethirtyeight.com/features/the-queen-of-code/) (2015), a documentary film about Grace Hopper produced by FiveThirtyEight.

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│ United States Navy rear admirals (lower half) │ Female admirals of the United States Navy
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│ Recipients of the Legion of Merit │ Harvard University people │ Vassar College faculty
│ People from New York City │ Vassar College alumni │ Yale University alumni
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│ 20th-century American mathematicians │ 20th-century American scientists │ 20th-century women scientists
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