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The Contributions of Grace Hopper

Rear Admiral Grace Hopper (formerly known as Commodore - the equivalent of Brigadier General in the Army) was an American computer scientist born December 9th 1906 in New York.

Hopper graduated Phi Beta Kappa (the oldest and most prestigious academic honour society in the US) from Vassar College, New York in 1928 with a bachelor's degree in Mathematics and Physics. Two years later, Hopper attended Yale University, where she earned her Master's and PhD in Mathematics. She then began teaching Mathematics and Physics in Vassar College and during a one year sabbatical leave, studied with the famous mathematician Richard Courant at New York University.

Early in World War II she had tried to enlist in the Navy but after being rejected for being too old and her weight to height ratio being too low, Hopper managed to get an exemption and joined the Navy WAVES (Women Accepted for Voluntary Emergency Service). In 1944 she was assigned to the Bureau of Ships Computation Project at Harvard University as a lieutenant.

Alongside Howard Aiken and their team, they produced an early prototype of the electronic computer, the IBM Automatic Sequence Controlled Calculator (ASCC), called Mark I. The Mark I was comprised of 765,000 parts and weighed five tons, using paper tape for input and typewriters for output. The machine which was contained in a 51 feet long and 8 feet high steel frame was operated using a fifteen meter drive shaft and a 3.7kW electric motor. This precursor of the modern computer was the first of its kind and was crucial in the war effort. Mark I computed tables free of human error for designs of navy equipment such as torpedoes and underwater detection systems. The MARK I also computed tables for rocket trajectories and calibrations for minesweepers. Hopper wrote the 561-page user manual for the MARK I. This user manual, *A Manual of Operation for the Automatic Sequence Controlled Calculator* was one of the first publications of a digital computer program. Aiken and Hopper built MARK I's successor, the MARK II. The MARK II is known as the first computer with a recorded instance of an actual bug stopping operation. The moth can be seen taped in her log book with the note "*first actual case of a bug being found*" at the Smithsonian Institution's National Museum of

American History. While Hopper did not coin the phrase bug, she is credited with popularizing the term.

In 1949 Grace Hopper joined Eckert-Mauchly Computer Corp. The company built new computer designs for commercial and military applications. Here she began working on the Universal Automatic Computer (UNIVAC I), the first commercial computer. The UNIVAC I was a decimal machine, consisting of 5,000 vacuum tubes and could perform roughly 1,905 operations per second running on a 2.25 MHz clock. It recorded its output on a tape. Hopper believed that computers had the potential to be used by a wider audience, not just by programmers. With this belief in mind, she explored ideas on automatic programming with the development of her first compiler, the A-0. Nowadays, the A-0 is considered to have functioned more as a linker than a compiler. The A-0 translated symbolic mathematical code into machine code. Hopper gathered the subroutines she had been using and put them on a tape, each identifiable by a call number. To execute one of these sub-routines she would then call it using its call number, the machine would find it on the tape and execute the routine. Upon completion of her first compiler, Hopper was met with harsh criticism. During an interview Hopper said - "*nobody would touch it because, they carefully told me, computers could only do arithmetic; they could not do programs. It was a selling job to get people to try it. I think with any new idea, because people are allergic to change, you have to get out and sell the idea*". Nevertheless, Hopper and her team continued to improve on the A-0, and produced versions A-1 and A-2. The A-2 was the first compiler to gain popularity. Hopper's work was an important step to the development of programming languages.

Continuing with her belief that programming should be made accessible to all and written in English, she developed the B-0 compiler, later known as FLOW-MATIC in 1956. FLOW-MATIC was the first programming language to use English words to express operations; it was aimed to be used for business tasks such as automatic billing and payroll calculation, unlike FORTRAN or MATH-MATIC, which used mathematical symbols. Using FLOW-MATIC, Hopper was able to make the UNIVAC I and II understand twenty statements in English. Again, she was met with criticism when she recommended that an entire programming language be developed using English words. She was told very quickly that she could not do this because computers did not understand English. In spite of this in 1952, Hopper published the first paper on compilers – "*The Education of a Computer*" in which she described fundamental principles in programming and anticipated future developments.

In 1959, Hopper took part in the Conference on Data Systems Languages (CODASYL) as a technical advisor. The aim of this meeting was to develop a programming language for business that was approachable to a wide range of different sectors. This led to the development of COBOL (COmmon Business-Oriented Language) which was influenced by Hopper's previous

work, FLOW-MATIC. Grace Hopper, often considered the "*Godmother of COBOL*", went on to say that COBOL was – "*95% FLOW-MATIC*". FLOW-MATIC contributions include: (i) long variable names and (ii) English words for commands. Hopper and the rest of the team created a readable language with as much machine-independence as possible in the hope to make computer programs accessible to all sectors. Many of the oldest large business systems still use COBOL today, around 43% of banking systems rely heavily on the FLOW-MATIC successor.

Rear Admiral Grace Hopper was awarded many medals and titles, including -

(i)   Defense Distinguished Service Medal, the highest decoration given to those who did not participate in combat (1987)

(ii)   Yale's Wilbur Lucius Cross Medal (1972)

(iii)   The first woman to be named a distinguished fellow of the British Computer Society (1973)

(iv)   The Presidential Medal of Freedom awarded by President Barack Obama (2016)

(v)   The National Medal of Technology awarded by President George Bush (1991)

(vi)   In 1996, the Navy commissioned the *USS Hopper*, a guided military destroyer

(vii)   In 2017, Hopper College at Yale University was named in her honor

Rear Admiral Grace Hopper is considered one of the first coders and a pioneer in the field of software engineering, whose contributions to Computer Science are still widely used today. In addition to her accomplishments, Hopper's work continues to inspire and encourage women to become part of the programming world with the *Grace Hopper Celebration of Women In Computing Conference* created in her honour.