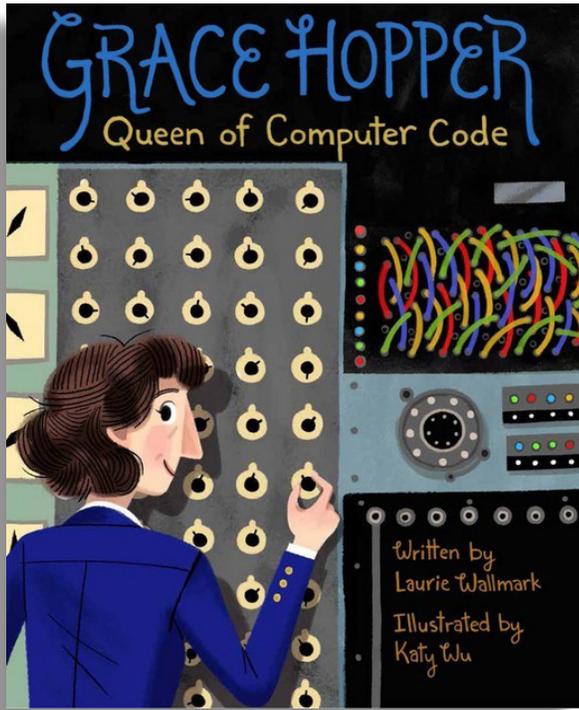


A Common Core State Anchor Standards and Next Generation  
Science Standards-Aligned Discussion & Project Guide for Grades K-5



# GRACE HOPPER: QUEEN OF COMPUTER CODE

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Written by Laurie Wallmark

Illustrated by Katy Wu

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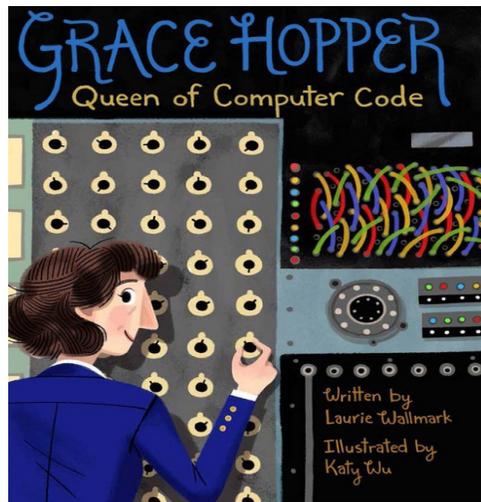
Who was Grace Hopper? A software tester, workplace jester, cherished mentor, ace inventor, avid reader, naval leader-AND rule breaker, chance taker, and troublemaker. Grace Hopper coined the term "computer bug" and taught computers to "speak English." Throughout her life, Hopper succeeded in doing what no one had ever done before. Delighting in difficult ideas and in defying expectations, the insatiably curious Hopper truly was "Amazing Grace" . . . and a role model for science- and math-minded girls and boys.

Guide Created by Debbie Gonzales, MFA  
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**Reference:** Deans, Edwina et al. *Extending Mathematics*. New York: American Book Company, 1968.



## Pre-Reading Discussion Questions

Consider the book's front cover:

- Describe the machine featured in the illustration. Note its size, as compared to the woman depicted in the picture. Predict the purpose of this machine. What do you think its function might be? Explain your answer.
- The title of the book is *Grace Hopper: Queen of Computer Code*. Tell all that you know about computer code.
- If the woman in the illustration is being referred to as a queen. Predict what she has done to earn that title.
- Study the woman's expression. Describe how she is feeling while working on the machine. Guess why she feels the way she does.
- Considering the visual clues discussed, determine what you this story is going to be about. Explain your answer.

Meet the author - Laurie Wallmark:

- Ms. Wallmark loves learning. She has earned an MFA in writing for children and young adults, and college degrees in biochemistry and information systems. Consider how her passion for writing and science might inspire Ms. Wallmark to write a book about a person like Grace Hopper.
- Ms. Wallmark teaches classes in writing computer code. Tell all that you know about computer codes or operating systems. Discuss things about computers you'd like to learn more about.
- Ms. Wallmark is very knowledgeable about topics such as binary arithmetic, algorithms, and writing non-fiction. To learn more about this interesting author, access her website at [www.lauriewallmark.com](http://www.lauriewallmark.com).



Meet the illustrator - Katy Wu:

- In an [interview with consultant Kathy Teamean](#), illustrator Katy Wu said that she's been illustrating since she was a child. Today, she works with animation, too. Discuss how her life-long interest in artistic expression has prepared her for her career in the arts today.
- Ms. Wu's advice for those who would like pursue their dream of being an artist is to "Practice often and work smart." Consider her message. Tell what it means to 'work smart.'
- *Grace Hopper: Queen of Computer Code* is Ms. Wu's first picture book. She says that she would like to write and illustrate her own picture book someday. Discuss how the experience of illustrating this book may have inspired Ms. Wu to create a story of her own.
- To learn more about Ms. Wu and to observe examples of her artwork, access <http://katycwwu.tumblr.com/archive>.



## Post-Reading Discussion Questions

When Grace's mother discovered the many jumbles of clock parts scattered around the house, all she could do was laugh. After all, Grace was just being Grace.

- Tell why Grace's inquisitive nature did not make her mother angry.
  - Explain what the phrase "Grace being just being Grace" means.
  - Discuss how Grace learned to view problems as possibilities as a very early age.
  - Make a connection between Grace's childhood curiosity and the woman that she grew to become. Tell how her inquisitive nature served her well throughout her entire life.
- 

Grace did more in college than just study. Whenever there was fun or adventure to be found, she was always first in line. Her personal motto was: "Dare and Do."

- Excelling in schoolwork was very important to Grace. And, yet she enjoyed having fun and trying new things. Discuss Grace's adventurous nature. Do you think trying new things helped her in her studies and life's work? How so?
  - The word *dare* is defined as to take a risk, to be courageous and bold. Tell what the phrase "Dare and Do" means.
  - Explore how this phrase serves to define the way Grace lived her life.
  - Determine how her boldness and willingness to take a risk benefitted those around her.
- 

Even though Grace loved teaching, America was now at war and needed the best mathematicians to design weapons. Patriotic Grace wanted to help her country, so she tried to enlist in the Navy.

That proved to be a problem.

- The word *tenacity* is defined as determination, stubbornness, and perseverance. Explain why, in this instance, enlisting in the Navy proved to be a problem for Grace. Tell how she demonstrated tenacity as she convinced the Navy to allow her to come on board.
- Trace over the events of Grace's life. Identify times when her determination and perseverance paid off, for her and for others.
- To be *patriotic* means to love one's country and to be a good citizen. Consider how Grace's love for America defined her life's purpose.

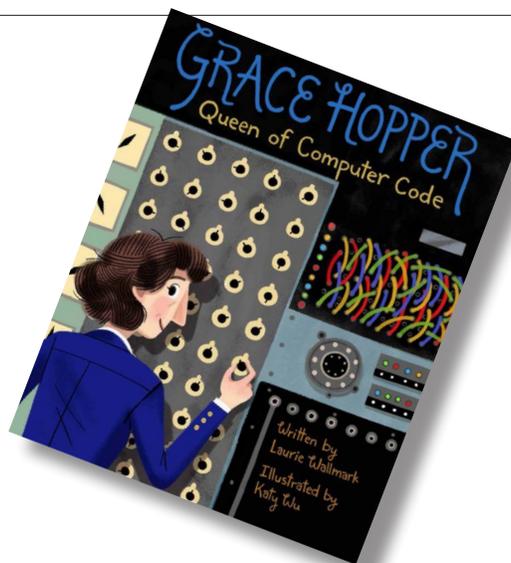


Grace glanced at the wall clock she had rigged to run backward. It reminded her to use her imagination. Unconventional thinking was often the key to solving problems.

- The word *unconventional* means very different, odd, and way out of the ordinary. Consider how Grace had been an unconventional thinker since childhood.
- Explain how thinking in unconventional ways can help to solve problems – large and small.
- Consider how her backward-running clock served as an expression of, not only thinking in unusual ways, Grace’s fun-loving nature.
- Define the word *imagination*. Tell how using one’s imagination helps to solve problems.

While she drew she asked herself questions. Why should people have to learn computer language? Why couldn’t computers learn people language?

- Consider why Grace asked questions when seeking answers for problems. Explain how this process helped her discover solutions.
- Notice that Grace was doing something fun while attempting to solve problems. Determine how the act of drawing creatures helped her to discover answers to the questions she wrestled with.
- Identify another time when Grace took time away from her demanding work to have some fun. Describe the importance of balancing work and pleasure. Explain why some people might consider this to be an unconventional way to approach problem solving.
- Discuss how approaching problem solving by asking questions while sketching, or daring to fly in a propeller plane, or taping a bug in an official scientific logbook are just a few examples of “Grace just being Grace”.



## Binary Code

"Let [people] write their programs in English. It was common sense.."

*Grace Hopper was the first programmer to believe that computer programs could be written in English rather than complicated 'binary code'. Binary code is a coding system using the binary digits 0 and 1 to represent a letter, digit, or other character in a computer or other electronic device.*

*Our standard numeration system, known as base-ten, uses numbers from 0 to 9. The binary code uses the base-two, numeration system, which uses only two digits – 0 and 1. Because of this, the base-two numeration system is ideal for use in electronic computers, where the two digits can be represented by the presence or absence of electric current (**Extending Mathematics**, pg. 78).*

*The objective of this activity is to analyze rows of 'lights' printed to represent a binary code by equating the base-two value as the equivalent value in base-ten. To do so, students are instructed to use a polynomial formula to calculate the results. Consider the difficulty and precise attention to detail computing mathematics in this way entails. Determine how this experience to better understand the intensity and intelligence of Grace Hopper and her life's work.*

### Materials:

- Bit Strip Worksheet (Guide, pg. 7)
- Binary Code Answer Sheet (Guide, pg. 8)
- Pencil

### Procedure:

- Write the numeral using base-two as indicated for each row lights represented as directed on worksheet. (See SAMPLE below.)
- Find the base-ten numeral that stands for the same number.
- Use the Binary Code Answer Sheet to check final answers.

**SAMPLE**



**Black dots = engaged**  
**White dots = open**

$(10101)_2$  ← **Base-two representation of binary code above**

$$\begin{aligned}
 (10101)_2 &= 1(2^4) + 0(2^3) + 1(2^2) + 0(2^1) + 1(2^0) \\
 &= 1(16) + 0(8) + 1(4) + 0(2) + 1(1) \\
 &= 16 + 4 + 1 \\
 &= 22
 \end{aligned}$$

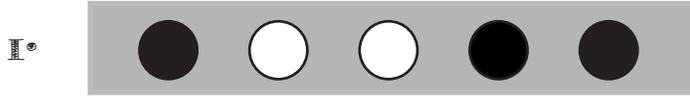
← **Base-ten polynomial pattern**

**Final answer** →  $(10101)_2 = (22)_{10}$

**Base-two      Base-ten**



## Bit Strip Worksheet



$$\begin{aligned}
 & \quad \quad \quad ( \_ \_ \_ \_ \_ )_2 \\
 ( \_ \_ \_ \_ \_ )_2 &= \_ (2^4) + \_ (2^3) + \_ (2^2) + \_ (2^1) + \_ (2^0) \\
 &= \_ (16) + \_ (8) + \_ (4) + \_ (2) + \_ (1) \\
 &= \_ + \_ + \_ \\
 &= \_ \_ \\
 ( \_ \_ \_ \_ \_ )_2 &= ( \_ \_ )_{10}
 \end{aligned}$$


---



$$\begin{aligned}
 & \quad \quad \quad ( \_ \_ \_ \_ \_ )_2 \\
 ( \_ \_ \_ \_ \_ )_2 &= \_ (2^4) + \_ (2^3) + \_ (2^2) + \_ (2^1) + \_ (2^0) \\
 &= \_ (16) + \_ (8) + \_ (4) + \_ (2) + \_ (1) \\
 &= \_ + \_ + \_ \\
 &= \_ \_ \\
 ( \_ \_ \_ \_ \_ )_2 &= ( \_ \_ )_{10}
 \end{aligned}$$


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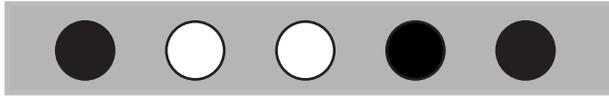


$$\begin{aligned}
 & \quad \quad \quad ( \_ \_ \_ \_ \_ )_2 \\
 ( \_ \_ \_ \_ \_ )_2 &= \_ (2^4) + \_ (2^3) + \_ (2^2) + \_ (2^1) + \_ (2^0) \\
 &= \_ (16) + \_ (8) + \_ (4) + \_ (2) + \_ (1) \\
 &= \_ + \_ + \_ + \_ + \_ \\
 &= \_ \_ \\
 ( \_ \_ \_ \_ \_ )_2 &= ( \_ \_ )_{10}
 \end{aligned}$$



# Bit Strip Worksheet Answer Sheet

1.



$$(\text{---})_2$$

$$\begin{aligned} (10011)_2 &= 1(2^4) + 0(2^3) + 0(2^2) + 1(2^1) + 1(2^0) \\ &= 1(16) + 0(8) + 0(4) + 1(2) + 1(1) \\ &= 16 + 2 + 1 \\ &= 19 \end{aligned}$$

$$(10011)_2 = (19)_{10}$$


---

2.



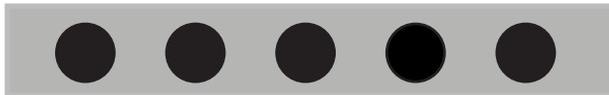
$$(11001)_2$$

$$\begin{aligned} (11001)_2 &= 1(2^4) + 1(2^3) + 0(2^2) + 0(2^1) + 1(2^0) \\ &= 1(16) + 1(8) + 0(4) + 0(2) + 1(1) \\ &= 16 + 8 + 1 \\ &= 25 \end{aligned}$$

$$(11001)_2 = (25)_{10}$$


---

3.



$$(11111)_2$$

$$\begin{aligned} (11111)_2 &= 1(2^4) + 1(2^3) + 1(2^2) + 1(2^1) + 1(2^0) \\ &= 1(16) + 1(8) + 1(4) + 1(2) + 1(1) \\ &= 16 + 8 + 4 + 2 + 1 \\ &= 31 \end{aligned}$$

$$(11111)_2 = (31)_{10}$$



## The Life and Times of Grace Hopper

"I have insatiable curiosity, Every time you solve a problem, another one shows up behind it. That is the challenge."

Objective: To present and interpret key details of text in a visual manner.

### Materials:

- Timeline Strips (Guide, pgs. 10)
- Timeline Tabs (Guide, pgs. 11-15)
- Poetry Labels (Guide, pg. 9)
- Tape
- Scissors
- Pencil
- *Grace Hopper: Queen of Computer Code*

### Procedure:

- Using scissors, trim around the borders of the Timeline Strips, Timeline Tabs, and Poetry Tabs.
- Using tape, construct timeline by securing strips together as directed on the Timeline Strips.
- Lay completed Timeline on a flat surface.
- Match the dates printed on the Timeline Tabs close to the associating date along the completed Timeline. Note that the tabs placed on the right reflect important dates in history, while the tabs on the right document events in Grace Hopper's life.
- Correlate the Poetry Labels with events described in Timeline Tabs, indicating the times in Grace Hopper's life when she demonstrated the actions described on the label. (Note that Poetry Label text is derived from the list poem printed on the first pages of *Grace Hopper: Queen of Computer Code*.)



### Poetry Labels

Software tester.

Clever thinker.

Order seeker.

Workplace jester.

Rule breaker.

Chance taker.

Lifelong tinker.

Cherished mentor.

Ace inventor.

Naval leader.

Well-known speaker.

Gremlin finder.



# Timeline Strips

	tape under 1910	tape under 1940	tape under 1960	tape under 1990
1900	1925	1950	1975	2000
1905	1930	1955	1980	2005
1910	1935	1960	1985	2010
1915	1940	1965	1990	2015
1920	1945	1970	1995	2020



## Timeline Tabs

World War I begins.

1914

The United States enters  
World War I.

1917

The Great Depression. (During this  
period of great financial problems,  
millions of people were out of work,  
and many went hungry.)

1929-  
1939

Zuse I computer is built in Germany  
(first functional, general-purpose  
digital computer).

1938

World War II.

1939-  
1945

The United States enters World War  
II after Japan bombs the Pearl Harbor  
navy base in Hawaii.

1941



Mark I computer is built (first functional, large-scale, general purpose computer in America).

1944

Mark II computer is built.

1947

UNIVAC I computer is built.

1951

First message is sent over ARPANET (precursor to the Internet).

1969

Altair 8800, considered to be the first personal computer, is introduced to consumers.

1975

World Wide Web is introduced to the public.

1991



**1906**

Grace Murray is born in New York City.

**1928**

Grace graduates with an honors BA degree in mathematics and physics from Vassar College. Inducted into the Phi Beta Kappa honor society.

**1930**

Grace graduates with an MA degree in mathematics from Yale University and marries Vincent Foster Hopper.

**1934**

Grace graduates with a PhD in mathematics from Yale University. Inducted into the Sigma Xi scientific honor society.

**1931-  
1943**

Grace teaches mathematics at Vassar College.

**1943**

Grace is sworn into the WAVES (Women Accepted for Volunteer Emergency Service), the women's branch of the US Navy.

**1949-  
1971**

Grace works at the Eckert-Mauchly Computer Corporation (later Sperry Rand).



**1953** Grace first thinks of using English words in programs.

**1957-1959** Grace develops FLOW-MATIC for the UNIVAC I computer.

**1959** Grace helps to develop specifications for COBOL (COmmon Business-Oriented Language) based on FLOW-MATIC.

**1966** Grace is forced to retire from the Navy because of her age.

**1967** Grace is recalled to active duty by the Navy.

**1967-1977** Grace works as Director of the Navy Programming Languages Group.

**1977-1986** Works as Special Staff to NAVDAC, the Naval Data Automation Command.



1983

Grace is promoted to Rear Admiral, Lower Half (previously called Commodore).

1986

Grace retires a second time from the Navy, at age 79.

1986-  
1991

Grace works at Digital Equipment Corporation.

1992

Grace Murray Hopper dies and is buried at Arlington National Cemetery with full military honors.

2016

The United States Naval Academy breaks ground on a new building for Cyber Security Studies, which will be named after Grace Hopper when completed in 2019.

2016

Grace Hopper is awarded the Presidential Medal of Freedom, the nation's highest civilian honor.



## A Bio-Pyramid

"Humans are allergic to change. They like to say, "We've always done it this way." I try to fight that.

*Use the Bio-Pyramid below to summarize facts about Grace Hopper's amazing life. Note that it contains eight lines to be filled out with specific details, lines beginning with one word and expanding to eight. Illustrate your work in the space provided. Share completed Bio-Pyramid and illustrations with the class.*

### Grace Hopper

\_\_\_\_\_

Two words describing Grace.

\_\_\_\_\_

Three words describing Grace's childhood

\_\_\_\_\_

Four words describing a problem Grace had to overcome.

\_\_\_\_\_

Five words stating one of her accomplishments.

\_\_\_\_\_

Six words stating a second accomplishment.

\_\_\_\_\_

Seven words stating a third accomplishment.

\_\_\_\_\_

Eight words stating how the world benefited from Grace Hopper's accomplishments.



## Common Core State Standards

### English Language Arts Standards » Anchor Standards » Reading

		Discussion Questions	Binary Code	Timeline	Bio-Pyramid
CCSS.ELA-Literacy.CCRA.R.1	Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.	●		●	●
CCSS.ELA-Literacy.CCRA.R.2	Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.	●	●	●	●
CCSS.ELA-Literacy.CCRA.R.3	Analyze how and why individuals, events, or ideas develop and interact over the course of a text.	●		●	●
CCSS.ELA-Literacy.CCRA.R.4	Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and analyze how specific word choices shape meaning or tone.	●	●	●	●
CCSS.ELA-Literacy.CCRA.R.7	Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words			●	●
CCSS.ELA-Literacy.CCRA.R.10	Read and comprehend complex literary and informational texts independently and proficiently.	●	●	●	●

### English Language Arts Standards » Anchor Standards » Writing

CCSS.ELA-Literacy.CCRA.W.2	Write informative/explanatory texts to examine and convey complex ideas and information clearly and accurately through the effective selection, organization, and analysis of content.				●
CCSS.ELA-Literacy.CCRA.W.4	Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.				●
CCSS.ELA-Literacy.CCRA.W.8	Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.	●		●	●
CCSS.ELA-Literacy.CCRA.W.9	Draw evidence from literary or informational texts to support analysis, reflection, and research.	●	●	●	●

### English Language Arts Standards » Anchor Standards » Speaking & Listening

CCSS.ELA-Literacy.CCRA.SL.1	Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.	●	●	●	●
CCSS.ELA-Literacy.CCRA.SL.2	Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.	●	●	●	●
CCSS.ELA-Literacy.CCRA.SL.5	Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.	●		●	●

### Standards for Mathematical Practice

<b>Perform arithmetic operations on polynomials.</b>					
CCSS.Math.Content.HS A.APR.A.1	Understand that polynomials form a system analogous to the integers, namely, they are closed under the operations of addition, subtraction, and multiplication; add, subtract, and multiply polynomials.			●	
<b>The Number System</b>					
<b>Grade 6: Compute fluently with multi-digit numbers and find common factors and multiples.</b>				●	



## Next Generation Science Standards

			Discussion Questions	Binary Code	Timeline	Bio-Pyramid
<b>K-2.Engineering Design</b>						
	K-2-ETS1-1.	Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.	●		●	●
<b>Disciplinary Core Ideas</b>						
ETS1.A: Defining and Delimiting Engineering Problems						
		Asking questions, making observations, and gathering information are helpful in thinking about problems.	●	●	●	●
<b>3-5.Engineering Design</b>						
<b>Crosscutting Concepts</b>						
Influence of Science, Engineering, and Technology on Society and the Natural World						
		People’s needs and wants change over time, as do their demands for new and improved technologies. (3-5-ETS1-1)	●	●	●	●
		Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)	●	●	●	●

