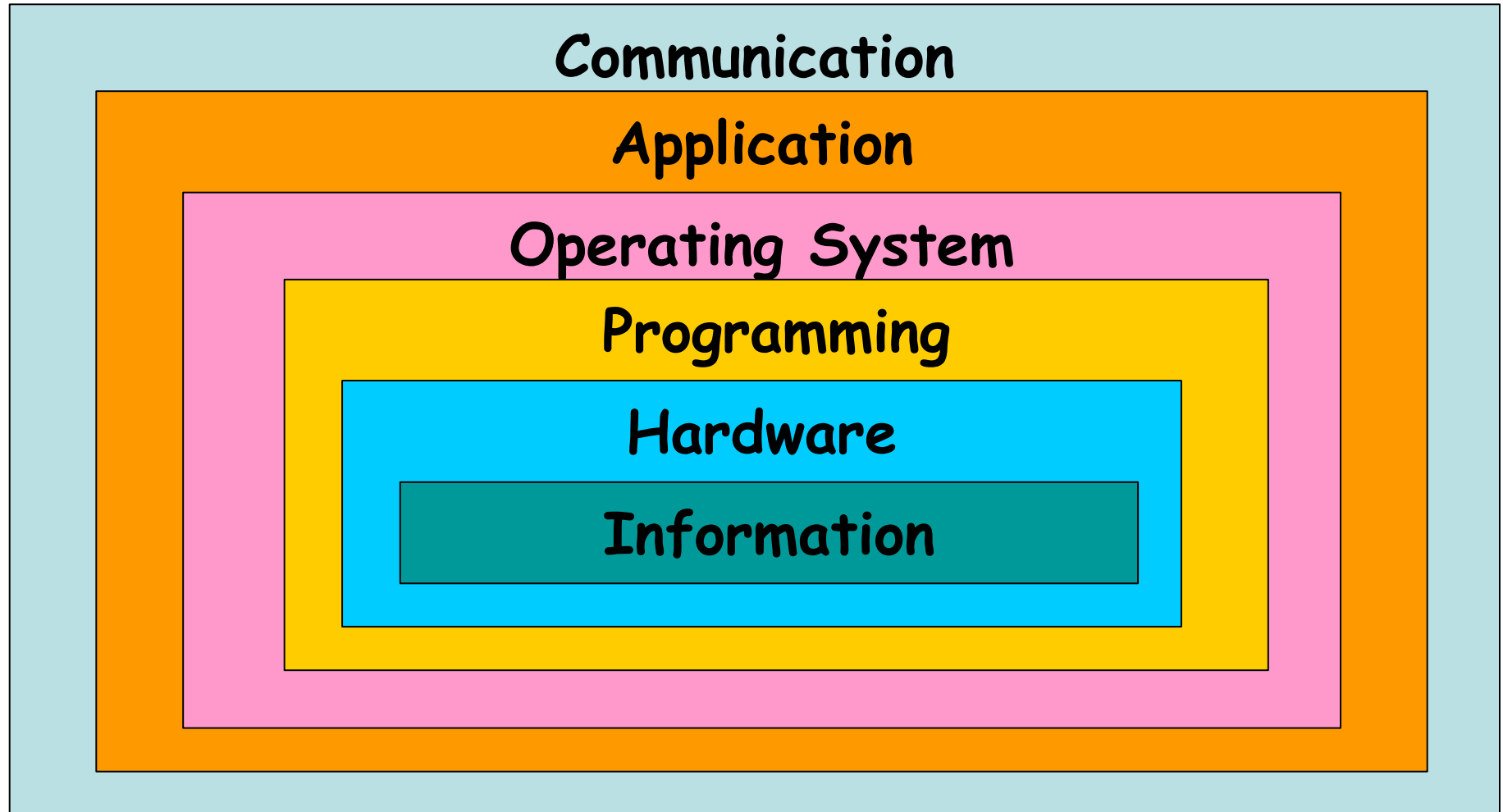


Chapter 2

Binary Values and Number Systems



Layers of a Computing System



Chapter Goals

- Know the different types of numbers
- Describe the relationship between bases 2, 8, and 16
- Conversion between bases
- Why in the world would you ever want to know this?

Numbers

Natural Numbers

Zero and any number obtained by repeatedly adding one to it.

Examples: 100, 0, 45645, 32

Negative Numbers

A value less than 0, with a - sign

Examples: -24, -1, -45645, -32

Numbers

Integers

A natural number, a negative number, zero

Examples: 249, 0, -45645, -32

Rational Numbers

An integer or the quotient of two integers

Examples: -249, -1, 0, $\frac{3}{7}$, $-\frac{2}{5}$

Natural Numbers

How many ones are there in 642?

$$600 + 40 + 2 ?$$

Or is it

$$384 + 32 + 2 ?$$

Or maybe...

$$1536 + 64 + 2 ?$$

Natural Numbers

Aha!

642 is $600 + 40 + 2$ in **BASE 10**

The **base** of a number determines the number of digits and the value of digit positions

Positional Notation

Continuing with our example...

642 in base 10 *positional notation* is:

$$\begin{aligned} 6 \times 10^2 &= 6 \times 100 = 600 \\ + 4 \times 10^1 &= 4 \times 10 = 40 \\ + 2 \times 10^0 &= 2 \times 1 = 2 \quad = 642 \text{ in base 10} \end{aligned}$$

This number is in
base 10

The power indicates
the position of
the number

Positional Notation

As a formula:

$$d_n * R^{n-1} + d_{n-1} * R^{n-2} + \dots + d_2 * R + d_1$$

R is the base
of the number

n is the number of
digits in the number

d is the digit in the
ith position
in the number

$$642 \text{ is } 6_3 * 10^2 + 4_2 * 10 + 2_1$$

Positional Notation

What if 642 has the base of 13?

$$\begin{aligned} + 6 \times 13^2 &= 6 \times 169 &= 1014 \\ + 4 \times 13^1 &= 4 \times 13 &= 52 \\ + 2 \times 13^0 &= 2 \times 1 &= 2 \\ &&= 1068 \text{ in base 10} \end{aligned}$$

**642 in base 13 is equivalent to 1068
in base 10**

Binary

Decimal is base 10 and has 10 digits:

0,1,2,3,4,5,6,7,8,9

Binary is base 2 and has 2 digits:

0,1

For a number to exist in a given number system, the number system must include those digits. For example, the number 284 only exists in base 9 and higher.

Bases Higher than 10

How are digits in bases higher than 10 represented?

With distinct symbols for 10 and above.

Base 16 has 16 digits:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, and F

Converting Octal to Decimal

What is the decimal equivalent of the octal number 642?

$$\begin{aligned} 6 \times 8^2 &= 6 \times 64 &= 384 \\ + 4 \times 8^1 &= 4 \times 8 &= 32 \\ + 2 \times 8^0 &= 2 \times 1 &= 2 \\ &&= 418 \text{ in base 10} \end{aligned}$$

Converting Hexadecimal to Decimal

What is the decimal equivalent of the hexadecimal number DEF?

$$\begin{aligned} D \times 16^2 &= 13 \times 256 = 3328 \\ + E \times 16^1 &= 14 \times 16 = 224 \\ + F \times 16^0 &= 15 \times 1 = 15 \\ &= 3567 \text{ in base 10} \end{aligned}$$

Remember, the digits in base 16 are
0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F

Converting Binary to Decimal

What is the decimal equivalent of the binary number 1101110?

$$\begin{aligned} & 1 \times 2^6 = 1 \times 64 = 64 \\ + & 1 \times 2^5 = 1 \times 32 = 32 \\ + & 0 \times 2^4 = 0 \times 16 = 0 \\ + & 1 \times 2^3 = 1 \times 8 = 8 \\ + & 1 \times 2^2 = 1 \times 4 = 4 \\ + & 1 \times 2^1 = 1 \times 2 = 2 \\ + & 0 \times 2^0 = 0 \times 1 = 0 \\ & \qquad \qquad \qquad = 110 \text{ in base 10} \end{aligned}$$

Arithmetic in Binary

Remember that there are only 2 digits in binary, 0 and 1

Position is key, carry values are used:

$$\begin{array}{r} 111111 \\ 1010111 \\ +1001011 \\ \hline 10100010 \end{array}$$



Carry Values

Subtracting Binary Numbers

Remember borrowing? Apply that concept here:

$$\begin{array}{r} 12 \\ 202 \\ 1010111 \\ - 111011 \\ \hline 0011100 \end{array}$$

Power of 2 Number System

Binary	Octal	Decimal
000	0	0
001	1	1
010	2	2
011	3	3
100	4	4
101	5	5
110	6	6
111	7	7
1000	10	8
1001	11	9
1010	12	10

Converting Binary to Hexadecimal

- Groups of Four (from right)
- Convert each group

10101011

1010

1011

A

B

10101011 is AB in base 16

Converting Decimal to Other Bases

Algorithm for converting base 10 to other bases

While the quotient is *not* zero:

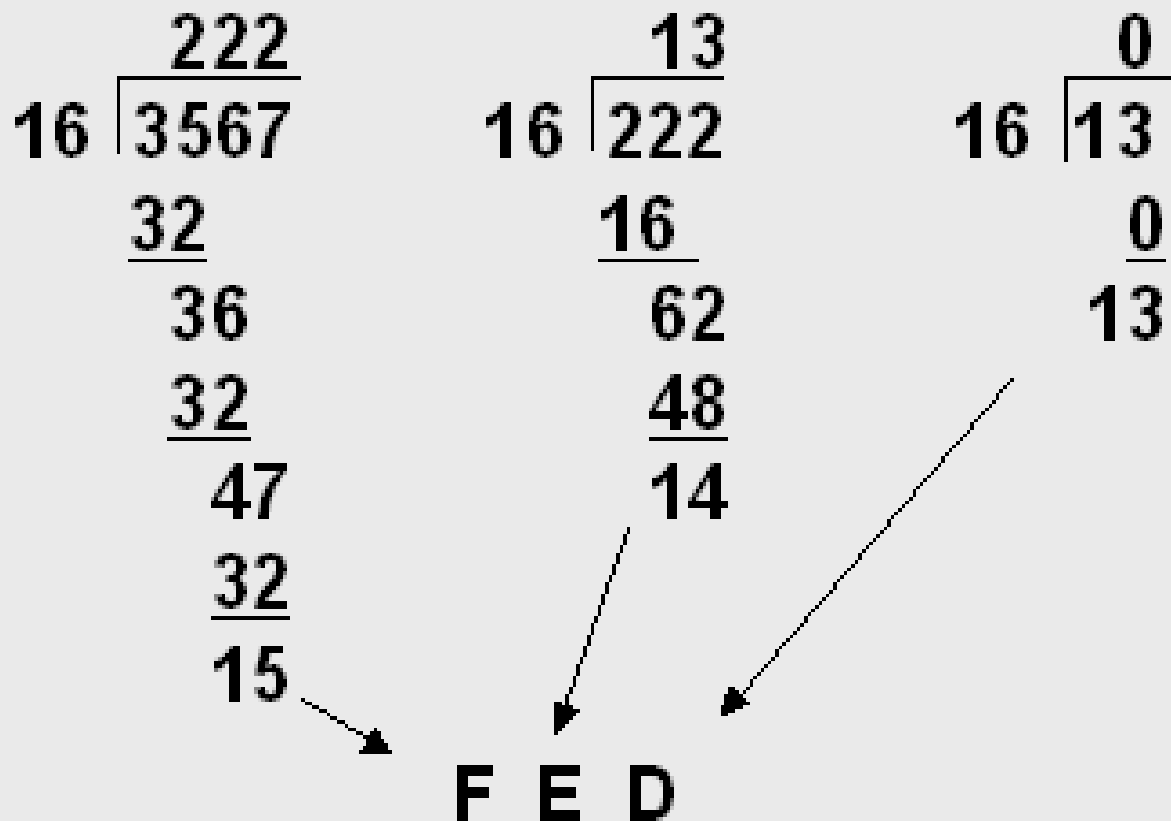
- * Divide the decimal number by the new base
- * Make the remainder the next digit to the left in the answer
- * Replace the original dividend with the quotient

Converting Decimal to Hexadecimal

Try a Conversion

The base 10 number 3567 is what number in base 16?

Converting Decimal to Hexadecimal



Binary and Computers

Binary computers have storage units called binary digits or bits

Low Voltage = 0

High Voltage = 1

all bits have 0 or 1

Binary and Computers

Byte 8 bits

The number of bits in a word determines the word length of the computer, but it is usually a multiple of 8

- 32-bit machines
- 64-bit machines etc.

Converting Binary to Decimal

What is the decimal equivalent of the binary number 1101110?

$$\begin{aligned} & 1 \times 2^6 = 1 \times 64 = 64 \\ + & 1 \times 2^5 = 1 \times 32 = 32 \\ + & 0 \times 2^4 = 0 \times 16 = 0 \\ + & 1 \times 2^3 = 1 \times 8 = 8 \\ + & 1 \times 2^2 = 1 \times 4 = 4 \\ + & 1 \times 2^1 = 1 \times 2 = 2 \\ + & 0 \times 2^0 = 0 \times 1 = 0 \\ & = 110 \text{ in base 10} \end{aligned}$$

- **Why, Why Me?**

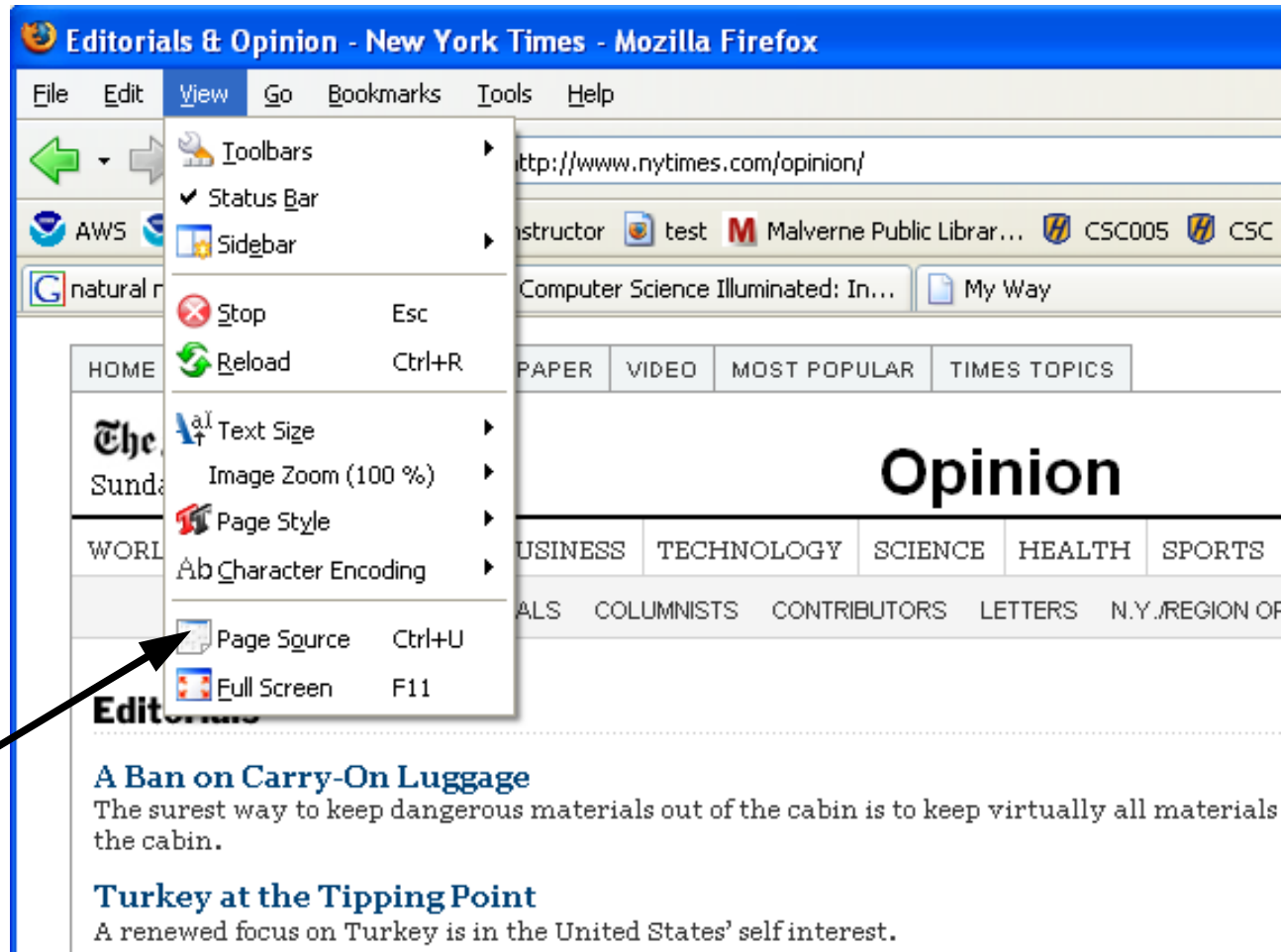
- **Why in the world would you ever want to know this?**

http://www.nytimes.com

The screenshot shows a Mozilla Firefox browser window with the title "The New York Times - Breaking News, World News & Multimedia - Mozilla Firefox". The address bar contains "http://www.nytimes.com/". The browser's menu bar includes "File", "Edit", "View", "Go", "Bookmarks", "Tools", and "Help". The toolbar shows navigation buttons (back, forward, refresh, stop, home) and a search bar. The browser's tab bar displays several tabs, including "AWS", "NWS", "DUATS", "DBMS-Instructor", "test", "Malverne Public Librar...", "CSC005", "CSC", "W", "X", and "CSC DUATS on the". The browser's status bar shows "natural numbers - Google Image ...", "Computer Science Illuminated: In...", "My Way", and "The New York Time".

The New York Times website is displayed below the browser window. The navigation bar includes "HOME PAGE", "MY TIMES", "TODAY'S PAPER", "VIDEO", "MOST POPULAR", and "TIMES TOPICS". The "TimesSei" logo is visible in the top right corner. The main content area features an advertisement for "AMERITRADE" with the text "Independence is the spirit..." and a portrait of a man. The main headline is "The New York Times" in a large, stylized font. Below the headline, the date "Sunday, September 10, 2006" and "Last Update: 10:27 PM ET" are displayed. A search bar is located below the date, with the text "NYT Since 1981" and a "Search" button. The main content area is divided into three columns. The left column contains "JOB MARKET", "REAL ESTATE", and "AUTOS". The middle column features the headline "Americans Gather on Eve of" and "Broken Ground". The right column contains "SPORTS »" and "Federer Wins".

View The Page Source



View
Source

HyperText Markup Language

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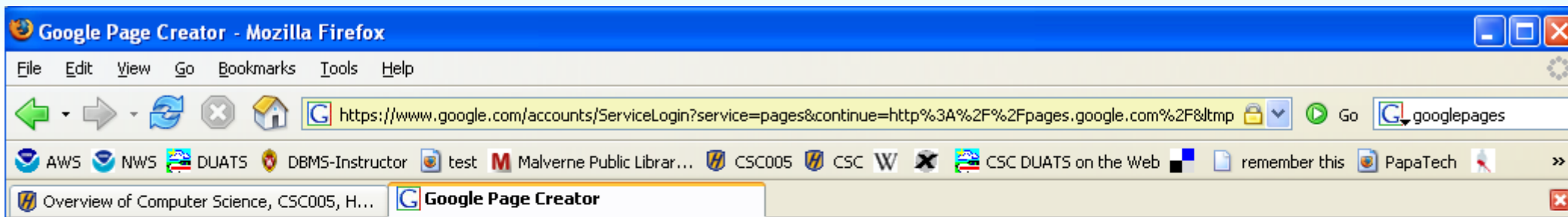
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```

http://pages.google.com



Welcome to Google Page Creator

Create your own web pages, quickly and easily.

Google Page Creator is a free online tool that makes it easy for anyone to create and publish useful, attractive web pages in just minutes.

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Build high-quality web pages without having to learn HTML or use complex software.

- **What you see is what you'll get.**

Edit your pages right in your browser, seeing exactly how your finished product will look every step along the way.

- **Don't worry about hosting.**

Your web pages will live on your own site at <http://yourgmailusername.googlepages.com>

Google Page Creator is a [Google Labs](#) project, and is still in an early testing phase. If you're interested in taking it for a test drive, login with your Gmail account to begin making pages. If you don't have a Gmail account and you have a mobile phone, you can [sign up here](#). We invite you to let us know what you think by sending us your [feedback and suggestions](#).

Sign in to Google Page Creator with your

Google Account

Email:

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AWS NWS DUATS DBMS-Instructor test Malverne Public Librar... CSC005 CSC W X CSC DUATS on the Web

Overview of Computer Science, CSC005, H... **Create a Google Account - Gmail**

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by Google BETA

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1 — 2 — 3

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To sign up, enter your mobile phone number below. We'll send you a text message with an invitation code to create your account. If you've already received a code, [skip to step two!](#)


Location: United States

Mobile phone number: +1
example: 650-555-1212

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Type the characters you see in the picture below.

SENSE


Letters are not case-sensitive

New message!
Your invitation code is: 123456

Homework

- Get a gmail account...
- ...if you don't want to use your mobile (or you don't have one), send an email to:
papacosta@gmail.com
- When you get an account, send me a message!
papacosta@gmail.com

The First Compiler...and Bug!

Grace Murray Hopper (December 9, 1906 - January 1, 1992) was an early computer pioneer. She was the first programmer for the Mark I Calculator and the developer of the first compiler for a computer programming language. Hopper was born **Grace Brewster Murray**. She graduated Phi Beta Kappa from Vassar College with a bachelor's degree in mathematics and physics in 1928 and 1934 became the first woman to receive a Ph.D. in mathematics.

She was well-known for her lively and irreverent speaking style, as well as a rich treasury of early "war stories". While she was working on a Mark II computer at Harvard University, her associates discovered a moth stuck in a relay and thereby impeding operation, whereupon she remarked that they were "debugging" the system. Though the term **computer bug** cannot be definitively attributed to Admiral Hopper, she did bring the term into popularity. The remains of the moth can be found in the group's log book at the Naval Surface Warfare Center in Dahlgren, VA

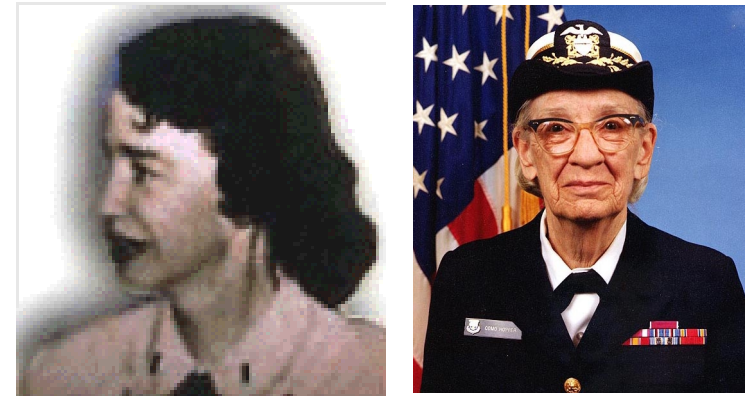


Photo # NH 96566-KN First Computer "Bug", 1945

9:2

9/9

0800 Antan started
 1000 " stopped - antan ✓ { 1.2700 9.027 847 025
 13'42 (032) MP - MC 2.130476415 9.027 846 785 correct
 (033) PRO 2 2.130476415 4.615925059(-2)
 correct 2.130476415
 Relays 6-2 in 033 failed special speed test
 in relay " 11,000 test.

1100 Started Cosine Taps (Sine check)
 1525 Started Multi Adder Test.

1545 Relay #70 Panel F (moth) in relay.

First actual case of bug being found.
 1630 antan started.
 1700 closed down.

Relay 2145
 entry 3376

Homework

- Read Chapter Two
- Come Back With Questions

...Have A Nice Night!