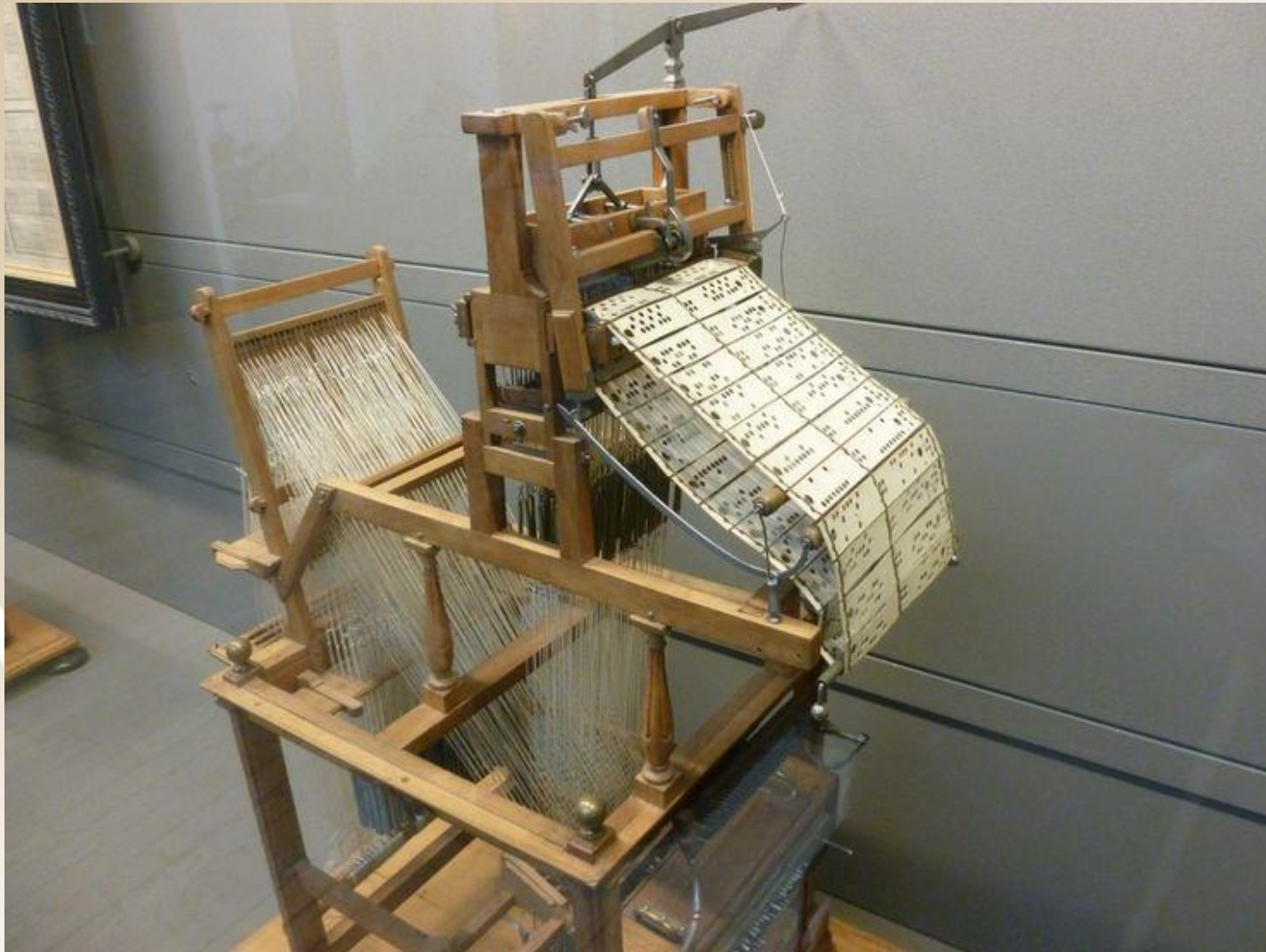# Sail out to Sea with the Women of Computing

Dr. Pete Sanderson

Professor Emeritus of Computer Science
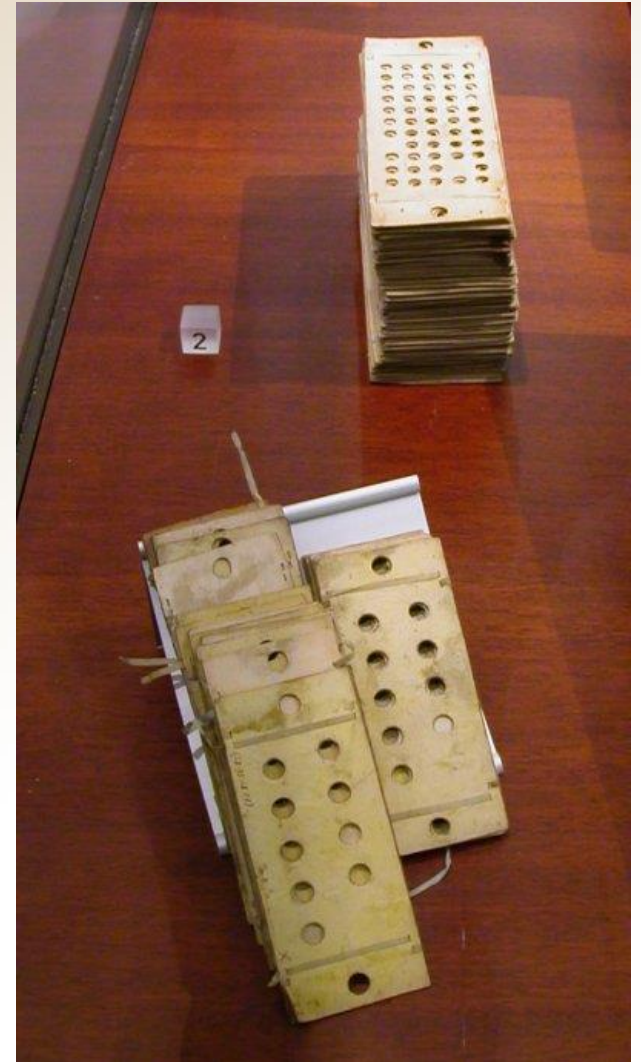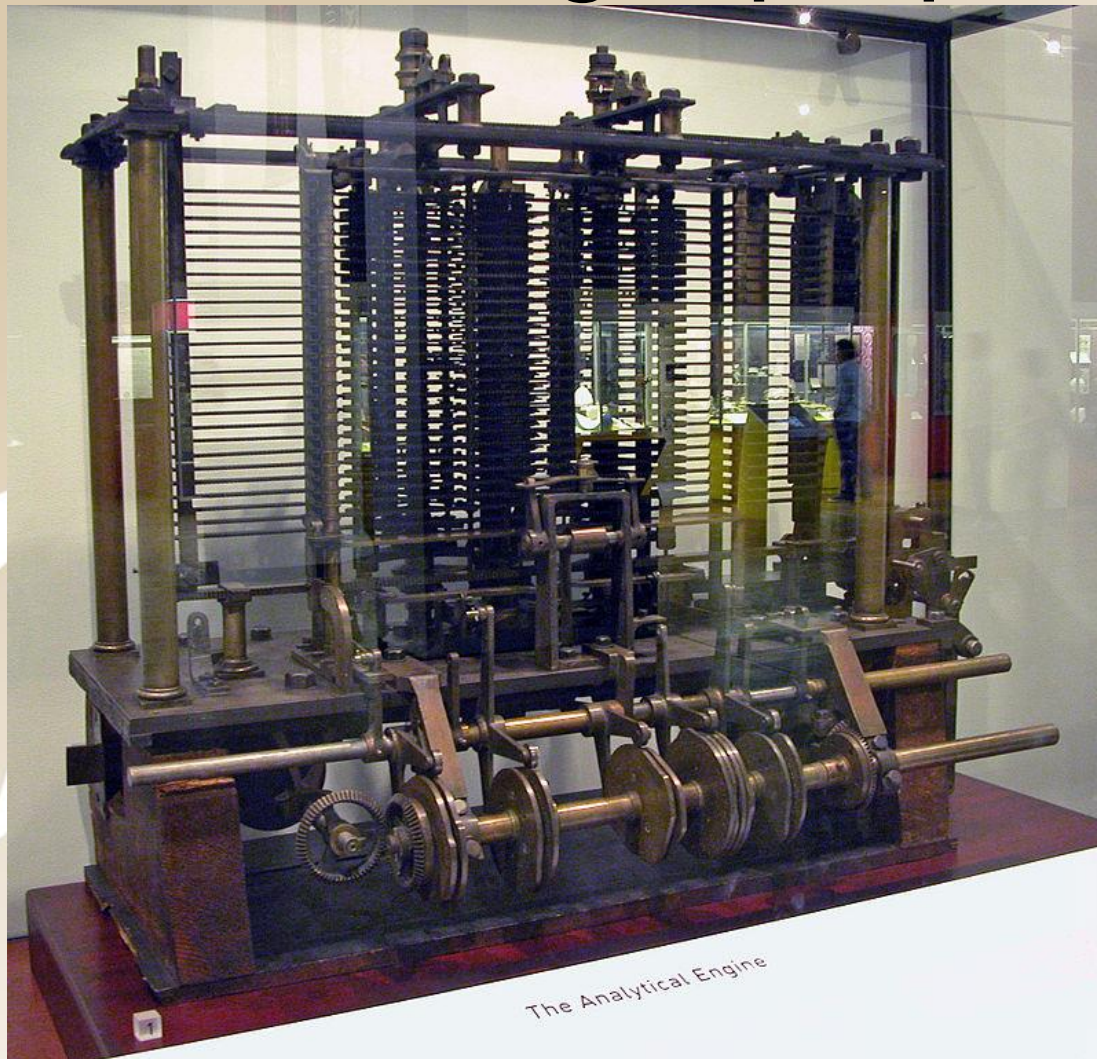
Otterbein University

6 November 2023

Jacquard Loom, invented 1801

Analytical Engine, Charles Babbage, proposed 1837

The Analytical Engine

Ada Lovelace

At age 17 (1833) and 25

Ada's Translation and Note

- In 1843, Babbage hired Ada to translate an article about the Analytical Engine.

- Article was written in French for a Swiss journal

- Ada supplemented the 8,000-word translation with a 20,000-word "note"

From the Translation

The various parts of the machine may be distinguished into two principal classes:

First, that relative to the *Operations*.
Secondly, that relative to the *Variables*.

When two numbers (Variables) are to be combined together, the machine … transfers the numbers to the mill. There, the apparatus having been disposed suitably for the required operation, this latter is effected, and, when completed, the result is transferred to the column of Variables which shall have been indicated.

Thus the mill is that portion of the machine which works, and the columns of Variables constitute that where the results are represented and arranged.

Today's equivalent

Example of addition using machine language of a modern computer.   A, B and C are variables located in memory (the "store"); R1, R2 and R3 are registers located in the CPU (the "mill")

`Load R1,A`   Load contents of A into R1

`Load R2,B`   Load contents of B into R2

`Add R1,R2,R3`   Add contents of R1 & R2, result to R3

`Store R3,C`   Store contents of R3 to C

Ada's Note and Algorithm

- "The Analytical Engine weaves algebraical patterns just as the Jacquard loom weaves flowers and leaves."

- "The engine might compose elaborate and scientific pieces of music…"

- Note G included an algorithm for computing the Bernoulli series.

- This is considered the world's first published computer program!

Algorithm detail from Note G

Number of Operation	Nature of Operation	Variables acted upon	Variables receiving results	Indication of change in the value on any Variable		Statement of Results
1	$\times$	${}^1V_2 \times {}^1V_3$	${}^1V_4, {}^1V_5, {}^1V_6$	$\left\{\begin{array}{l}{}^1V_2 \\ {}^1V_3\end{array}\right.$	$\left.\begin{array}{l}= {}^1V_2 \\ = {}^1V_3\end{array}\right\}$	$= 2n$ ....
2	$-$	${}^1V_4 - {}^1V_1$	${}^2V_4$	$\left\{\begin{array}{l}{}^1V_4 \\ {}^1V_1\end{array}\right.$	$\left.\begin{array}{l}= {}^2V_4 \\ = {}^1V_1\end{array}\right\}$	$= 2n - 1$ ....
3	$+$	${}^1V_5 + {}^1V_1$	${}^2V_5$	$\left\{\begin{array}{l}{}^1V_5 \\ {}^1V_1\end{array}\right.$	$\left.\begin{array}{l}= {}^2V_5 \\ = {}^1V_1\end{array}\right\}$	$= 2n + 1$ ....
4	$\div$	${}^2V_5 \div {}^2V_4$	${}^1V_{11}$	$\left\{\begin{array}{l}{}^2V_5 \\ {}^2V_4\end{array}\right.$	$\left.\begin{array}{l}= {}^0V_5 \\ = {}^0V_4\end{array}\right\}$	$= \frac{2n-1}{2n+1}$ ....
5	$\div$	${}^1V_{11} \div {}^1V_2$	${}^2V_{11}$	$\left\{\begin{array}{l}{}^1V_{11} \\ {}^1V_2\end{array}\right.$	$\left.\begin{array}{l}= {}^2V_{11} \\ = {}^1V_2\end{array}\right\}$	$= \frac{1}{2} \cdot \frac{2n-1}{2n+1}$
6	$-$	${}^0V_{13} - {}^2V_{11}$	${}^1V_{13}$	$\left\{\begin{array}{l}{}^2V_{11} \\ {}^0V_{13}\end{array}\right.$	$\left.\begin{array}{l}= {}^0V_{11} \\ = {}^1V_{13}\end{array}\right\}$	$= -\frac{1}{2} \cdot \frac{2n-1}{2n+1} = A_0$ ......

Ada's legacy

- Ada programming language

- Funded by US Department of Defense

- Once mandated for many DoD projects

- Developed 1977-1983

- Still in use today!

Fast-forward 100 years….

What was happening in 1943?

What was the definition of *computer*?

In December 1943, Vassar College mathematics professor **Grace Murray Hopper** joined the US Naval Reserve.

Grace Murray Hopper

US Naval Reserve, 1943-1966, 1967-1971, 1972-1986

Grace and the Mark I

- In 1944, Grace Hopper read the memoirs of Charles Babbage

- She soon joined the Mark I computer project at Harvard

- She wanted to make computers easier to program

- She designed "compilers" to translate English-like instructions into binary

COBOL Compiler Example

COBOL language to perform addition:

```
COMPUTE   C = A + B
```

COBOL compiler may translate this to:

```
Load R1,A
Load R2,B
Add R1,R2,R3
Store R3,C
```

then to its binary equivalent (01101010...)

COBOL

- **CO**mmon **B**usiness **O**riented **L**anguage
- Not the first language she helped develop, but the most famous.
- Developed in the 50s
- Still in use today!

The Bug
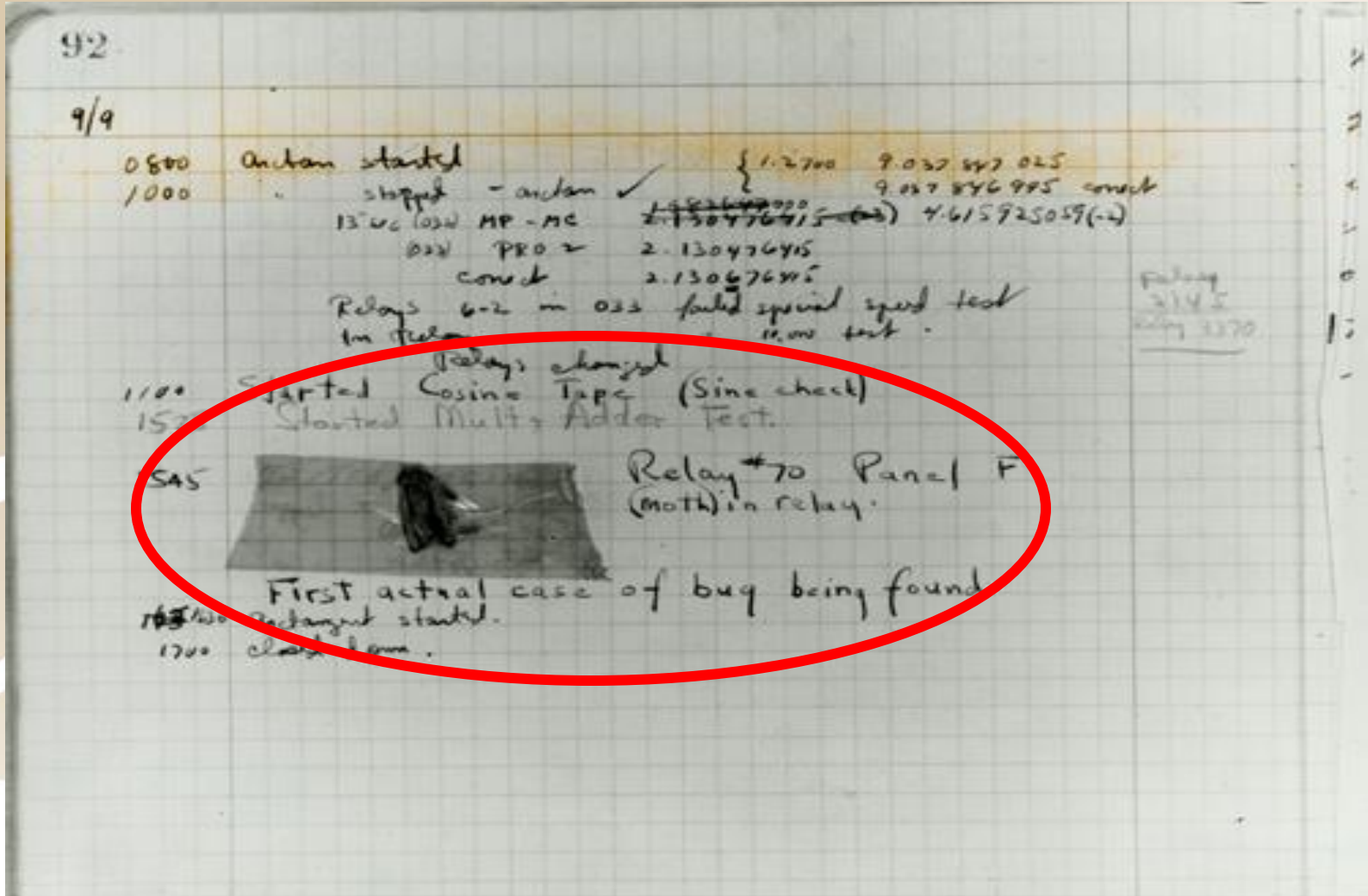
Moth that shorted a circuit in the Mark II computer

The Nanosecond

Famous Quote

"A ship in port is safe; but that is not what ships are built for. Sail out to sea and do new things."

-- John Augustus Shedd (1859-1928)
from his book *Salt from My Attic*

sometimes attributed to Grace Hopper

Legacy of "Amazing Grace"

- The Annual Grace Hopper Celebration of Women in Computing

- 2023 Celebration recently in Orlando FL

- ACM Grace Murray Hopper Award

- National Women's Hall of Fame 1994

- USS Hopper Naval destroyer 1997

- Presidential Medal of Freedom 2016

Meanwhile, over at UPenn…ENIAC

ENIAC

- **E**lectronic **N**umerical **I**ntegrator **A**nd **C**omputer
- Developed to generate artillery firing tables
- U. of Pennsylvania's Moore School of EE
- John Mauchly, J. Presper Eckert
  - After ENIAC they left to found the company now known as Unisys
  - Grace Hopper would join them in 1949

Programming ENIAC

- Each program required different circuit design
- This was done using modular circuits and plugboards
- Six "computers" were hired to program it
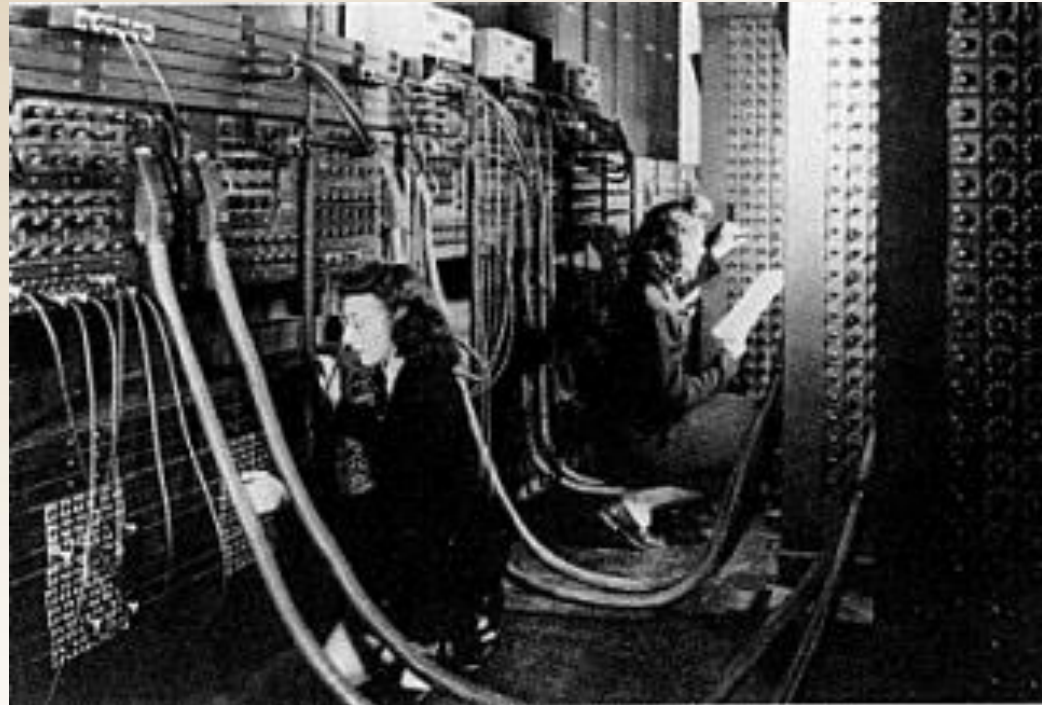
The 6 ENIAC Programmers

"Direct Programming"

- No programming manuals! All they had were circuit diagrams!

- ENIAC organized into 27 units with total of 18,000 vacuum tubes.

- 20 units to add & store, 3 to multiply, 1 to generate "clock" pulses

- Kay discovered the *master programmer unit* could implement loops and if-then!

"Pedaling Sheet"

- Jean, Betty and Kay translated calculations step-by-step into unit activations, constructing a table similar to Ada's.

- Each row is a step, each column is a unit, each cell contains its settings.

- They called the table a "pedaling sheet" like riding a bicycle one pedal at a time

- They did parallel programming! E.g. two simultaneous add results feed into multiply

Demo Day 15 Feb 1946

- Ruth, Fran and Marlyn joined after being released from another ENIAC project

- All 6 wrote and debugged the trajectory program before having access to ENIAC!

- Major public demonstration February 1946, birth of the information age

- Program ran correctly, calculating trajectory in 20 seconds versus human 30-40 hours!
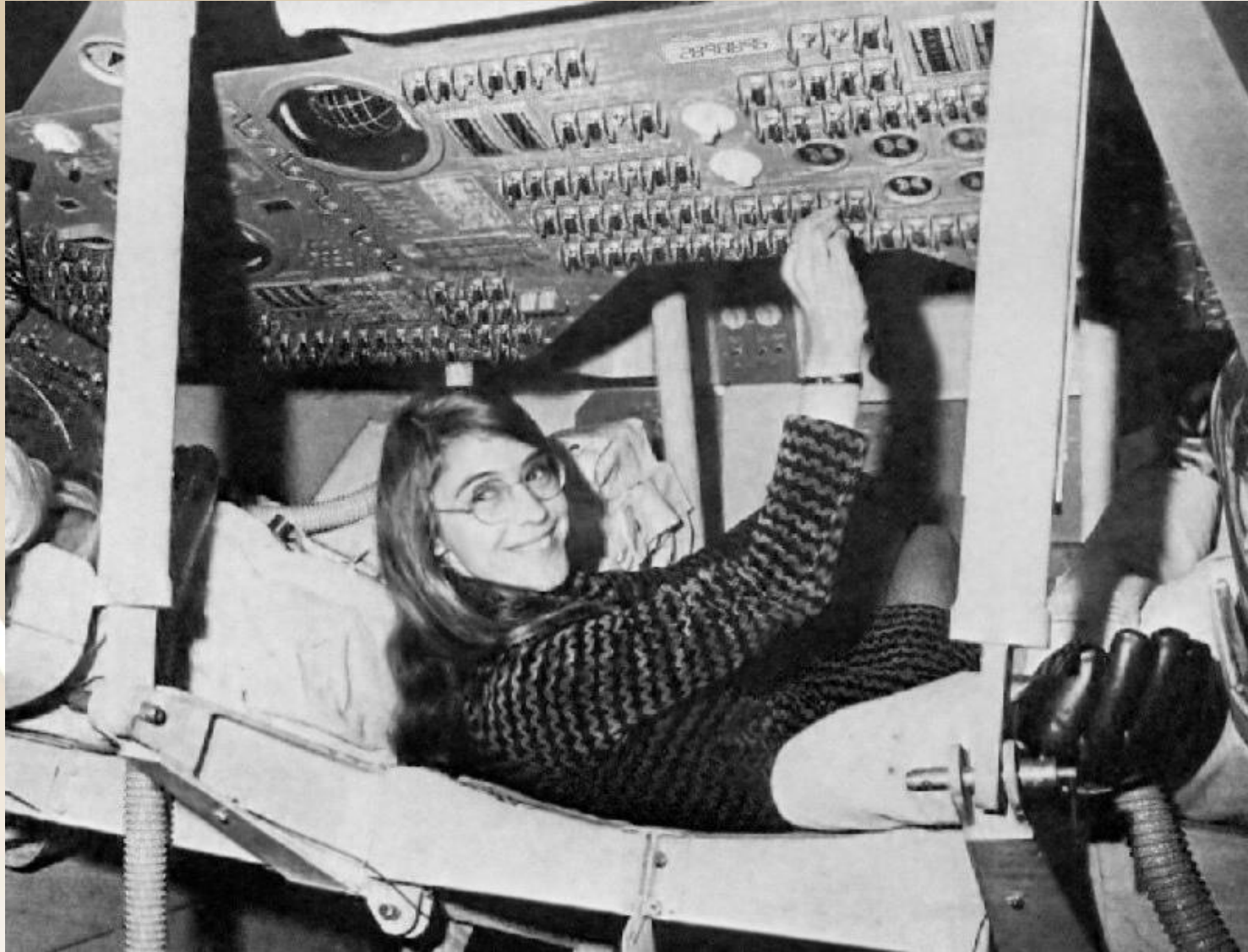
"One small step for (a) man…"

On 20 July 1969,
Neil Armstrong
took humankind's
first step on the moon

Ever wonder who
programmed the
Apollo 11 command module computer?

…meet Margaret Hamilton!

Margaret Hamilton

- Indiana native, taught high school math

- Joined MIT lab working for NASA

- Led the team that developed Apollo 11 fight control software

- Credited with coining the term *Software Engineering*

Mission Critical

Her software saved the Apollo 11 lunar landing when the on-board computer became overwhelmed with tasks.

It correctly prioritized them in real-time.

with source code listing for Apollo Guidance Computer, 1969

Full Circle

Margaret Hamilton, still active at 87, is a recipient of the **Augusta Ada Lovelace Award** from the Association of Women in Computing

Highest Honors

On November 22, 2016 Margaret Hamilton and Grace Hopper were awarded the **Presidential Medal of Freedom**, the highest civilian award in the United States.

© AFP/Getty Images

Katherine Johnson

- NASA Mathematician and Computer
- Calculated trajectories for Mercury flights. John Glenn requested her!
- Focus of *Hidden Figures* book and movie
- Presidential Medal of Freedom 2015

Jean Sammet

- COBOL co-developer
- Ada co-developer
- Programming Languages authority
- First female ACM President 1974-76
- Lovelace award 1989 NCWIT award 2013

Mary Shaw

- Institute for Software Research, CMU

- Software Engineering

- Abstract Data Types, foundation for Object-Oriented Programming

- Awarded the National Medal of Technology and Innovation

Qiheng Hu

- President of Internet Society of China

- Pattern Identification and Artificial Intelligence

- Led the drive to connect China to the Internet, 1994

- Internet Hall of Fame

Barbara Liskov

- One of the first women with Computer Science PhD (Stanford, 1968)

- Natural language translation, CLU language

- Liskov substitution principle (LSP) in O-O languages

- MIT Professor

- ACM Turing Award 2008

Shafi Goldwasser

- MIT and Weizmann Inst of Science in Israel
- Computational theory and cryptography
- ACM Turing Award 2012

Anita Borg

- Founded Systers, online network for women in technology in 1987
- Co-founded the Grace Hopper Celebration 1994
- Founded Anita Borg Institute for Women and Technology in 1997
- See AnitaB.org

Sally Floyd

- Network Research Group Berkeley National Labs
- Developed the network congestion control algorithms used by the Internet

Radia Perlman

- Digital Equipment Corp, Sun Microsystems, Dell
- Developed "Spanning Tree Protocol" algorithms for reliable delivery used by the Internet
- Known as "Mother of the Internet"
- Holds over 100 patents

Mary Lou Soffa

- Universities of Pittsburgh and Virginia

- Programming languages and optimizing compilers

- Mentor to many women in computing

- My first grad school advisor!

Joyce Statz

- First BGSU female tenured computer science professor, 1973-78

- 15 years at Texas Instruments, building specialty AI systems

- TereQuest startup, later sold to Borland

- Worked worldwide

The Logo Turtle at BGSU, 1974

- Joyce @ Syracuse: develop children's problem-solving skills by programming MIT's Logo Turtle

- Got a Logo Turtle for BGSU, programming for 5th graders

Where are we today?

The highest percentage of female computer science majors is 36%, when?
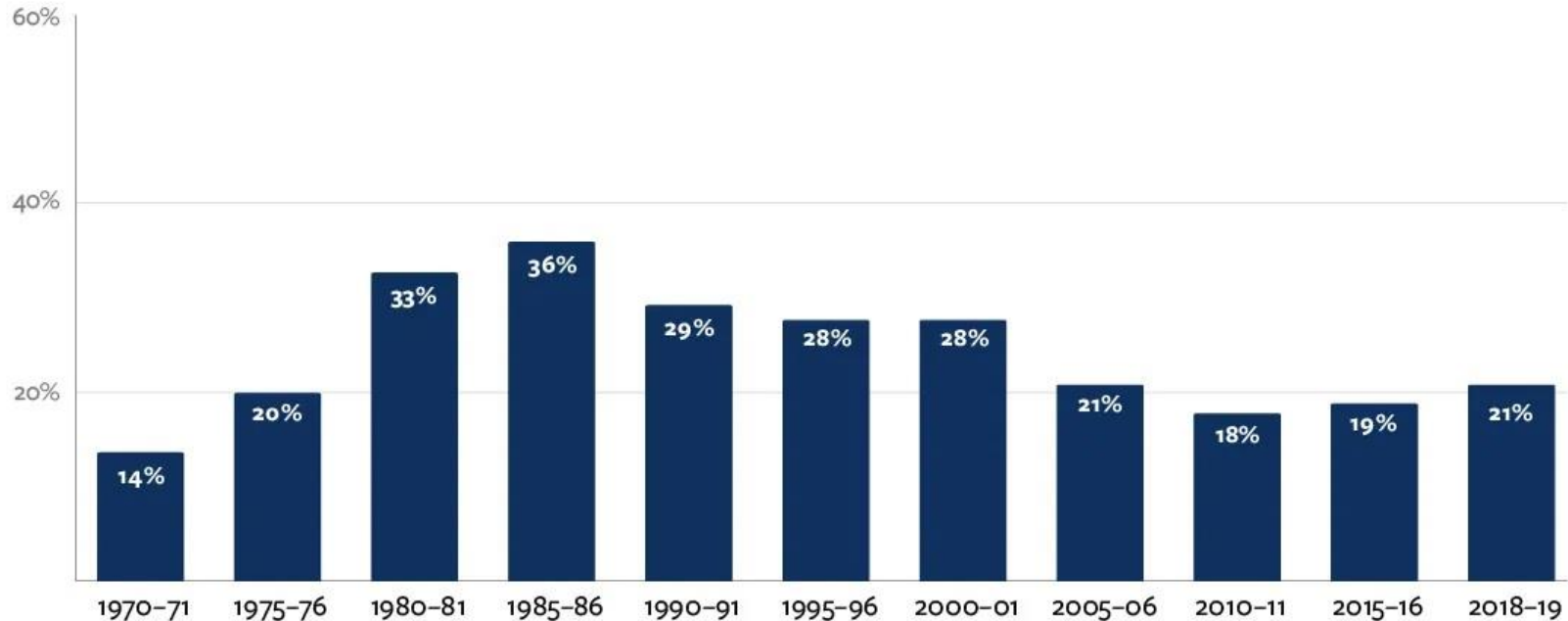
A.   1985

B.   2000

C.   2015

What is being done?

- Girls Who Code
- Code.org
- Systers (online forum for women in IT)
- Code To Inspire (girls & women in Afghanistan)
- National Center for Women & IT (NCWIT)
- Association for Women in Computing
- Anita Borg Institute for Women and Technology
- Grace Hopper Celebration of Women in Computing
- Computer Science Education Week

Book Resources
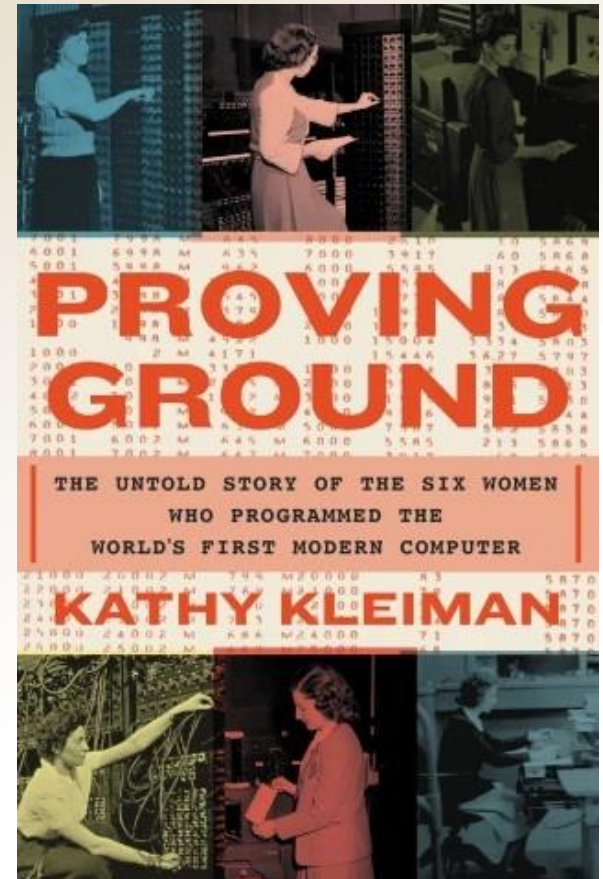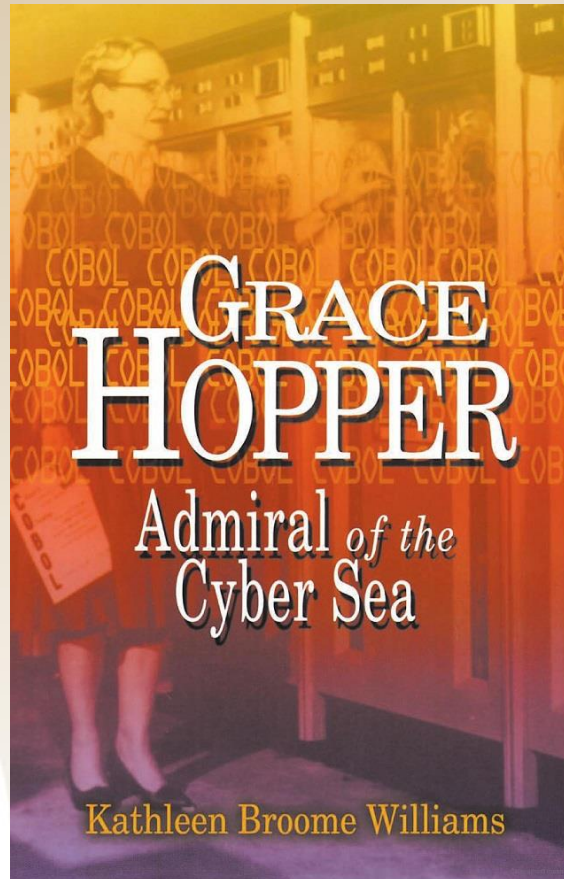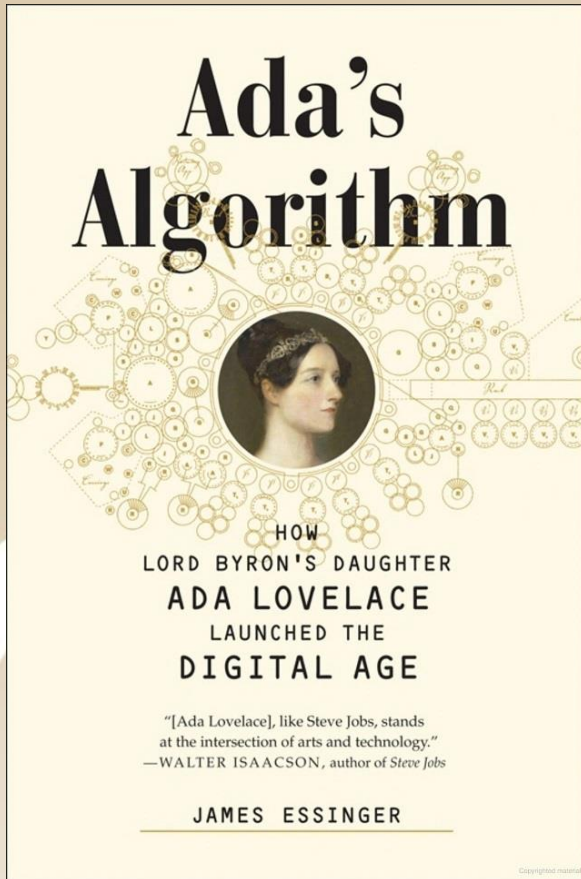
Thanks also to my Fall 2016 Software Engineering class for their research!