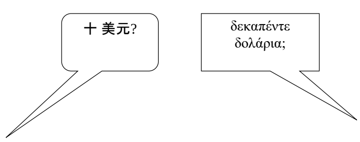
Early Computational Devices

Calculating and storage devices (including organic forms) from ancient times (pre-B.C.) up to the slide rule.

James Tam

Need For Tracking Amounts

- Even in ancient times there was a recognized benefit of trade and commerce.
- In the absence of a common language some means of communicating amounts was required.



Optional video: Recreation of non-verbal barter session

James Tam

Written/Symbolic Notations For Tracking Amounts

- Chapter 1: "History of Computing Technology" by Michael R. William.
  - I'll leave up to your personal interest to read this Chapter
  - We'll move straight onto the computational 'devices'

James Tam

Example Of Fingers As Computational Devices: Multiplication

- Likely there's many different ways that this can be done.
- One approach:
  - Only need to memorize multiplication tables up to 5 x 5
  - For values larger than 5 (up to 10) use the fingers of two hands to represent the numbers being multiplied.
  - The fingers of one hand each represent one of the numbers to be multiplied.
  - The number of fingers to be raised on a hand = (Number to be multiplied – 5).
  - The total number of fingers raised between the two hands is the number of 'tens'.

James Tam

Example Of Fingers As Computational Devices: Multiplication (2)

- Take the number of closed fingers on each hand (guaranteed to be less than or equal to be five under regular circumstances) and multiply the fingers on one hand by the fingers on the other hand. This yields the number of 'ones'
- Sum the tens and ones to get the product of the two numbers being multiplied.

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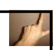
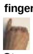


Representing Quantities With Fingers: Counting

- **Simplest case**: each digit is mapped to a number
  - Each digit (or the sum of the digits) raised represents a quantity
    - Mutually exclusive: digits cannot be raised and lowered independently of the others (if one digit is raised then none of the other digits can be raised).
  - Pros:
    - More clearly represents values than some of the other representations.
    - Easy enough to learn but only a limited number of values may be represented (0 – 10).
    - Cons:
  - Misunderstandings may still be possible (so this method comes with a disclaimer from the course instructor!)
    - Position may be mapped to values in some cultures!

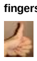
Position independent (# fingers not position for qty.)


Qty. =1


Qty. =3


Qty. =4

Position dependent (position not # fingers to indicate qty.)


Qty. =1


Qty. =2

Images: James Tam

James Tam

Representing Quantities With Fingers: Counting (2)

- **'Binary' approach**: Digits are mapped to values but each digit may be raised independently of the others.
  - Allows for a larger range of values to be represented
    - $2^{\text{number of digits}}$ = amount of numbers that can be represented
    - 2^{10} = 1024 possible numbers that can be represented

Optional video: illustrating the binary approach for representing values

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Representing Quantities With Fingers: Counting (3)

- Chinese finger notation: The individual joints of each finger as well as the left, center and right parts can each be used to represent quantities.

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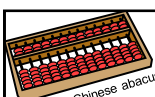
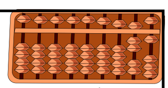

Chinese abacus

The Abacus


Japanese abacus

- The exact origins are unclear (Williams and many others)
  - Used by many cultures e.g. Chinese ("seun poon" / "swan pan"), Japanese (soroban)
  - Origin of word 'abacus': may come from the Semitic word abaq ('dust')
- Can actually be used for serious work (calculations in actual practice).
  - A competition was held between a trained operator of: an abacus and a electric calculating device.
  - The contest measured speed and accuracy (addition, subtraction, multiplication).
  - The operator of the abacus won four out of five contests.

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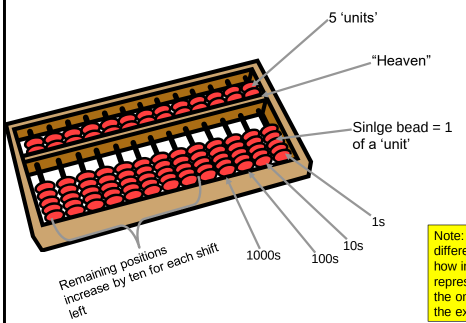
Image copywrite unknown

External Extra Videos:

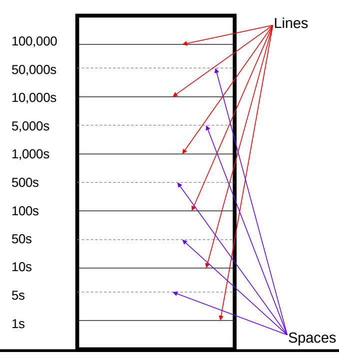
- The Abacus Vs. Calculator (old news footage)
  - https://www.youtube.com/watch?v=6YaLuh1QRM8
- Illustrating the high speed use of the abacus:
  - https://www.youtube.com/watch?v=6m6s-ulE6LY

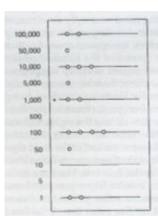
The Chinese Abacus As A Counting Mechanism



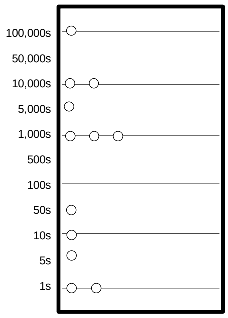
Note: there are different variations in how information is represented but this is the one you will see on the exam.

The European Table Abacus As A Counting Mechanism





Example Values: European Table Abacus



- Example: 128067
- NOTE: you won't get the scale (left) on the exam

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Influence Of The Abacus

- Until recently the abacus was used an actual tool for performing calculations.
- It's also influenced the English language.
  - Historically ~1200 AD 'Arithmetic' and 'abacus' became interchangeable
  - Romans: the pebbles used were called 'calculi' from which 'calculate' and 'calculus' were derived.

James Tam

Introduction: Early Computing Devices

- You should know the approximate time at which these devices were invented and used.
- You should also know the general use of these devices e.g., Astrolabe for determining time.
- Unless told otherwise (e.g., you are taught it in class): What you don't need to know is the exact and detailed use of these devices e.g., given that Gunter's Quadrant is set to a particular configuration what time of day is it in Italy?
- You should also know a bit about the people behind these devices (e.g., who they were, roughly when they lived)
  - Again the detail level covered in lecture will be sufficient for the exam.

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Astrolabe

- Often it's a two (or sometimes three) dimensional representation of the celestial sphere.
- Used for many different purposes:
  - Mapping the position of celestial bodies

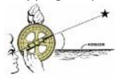

Image from: http://www.experiment-resources.com
(Listed as public domain)

  - Measure latitude / Determining approximate location
  - Determine time
  - Estimate the height of objects
  - Casting of horoscopes.

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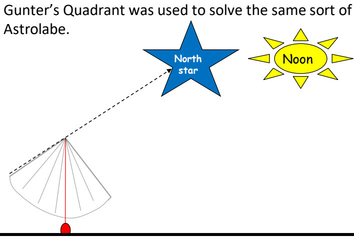
Gunter's Quadrant

From: www.sciencemuseum.org.uk/ (Last accessed Jan 2016)

- Edmund Gunter 1581 – 1626
- The quadrant was based on the astrolabe.
  - Astrolabe (circular)
  - Quadrant (folded into a quarter circle)
  - Gunter's Quadrant was used to solve the same sort of problems as the Astrolabe.



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External Extra Video: Using A Quadrant

- https://www.dailymotion.com/video/x2nfn6m

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The Proportional Compass

- Used by draftsmen to reduce and enlarge drawings in any given proportion.

From: http://www.computerhistory.org (last accessed Jan 2016)

The Sector

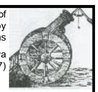
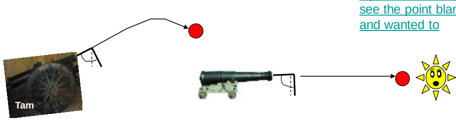


Image from: "A History of Computing Technology" by Williams

Original drawing: "La Nova Scientia" (N. Tartaglia 1537)

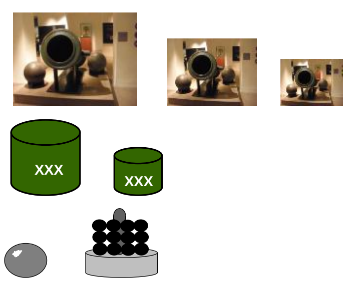
- Independently there were many publications that described this device (Williams)
  - 1584 to 1606 (Antwerp, London, Padua).
- The most widely copied version was created in Padua (1606: Galileo)
  - Early writings indicate that Galileo was working on the device in 1597 (or earlier).

Optional video: If you couldn't see the point blank explanation and wanted to



"Geometric And Military Compass"

- Name provided by Galileo Galilei: Initially used to solve artillery calculations all of which affected the range.



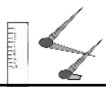
Early Computational Devices

- As seen they were put to many uses
- However their value was derided by scholars (who often preferred finding analytical solutions instead)
- William Oughtred (inventor of the slide rule)

*"..the true way of Art is not by Instruments…it is a preposterous course of **Vulgar Teachers**, to begin with instruments, and not with the Sciences, and so instead of Artists, to make their Scholars only **doers of tricks**, and as it were"*

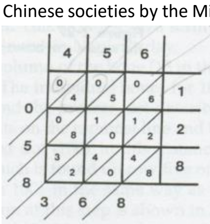
- As quoted in in F. Cajori, "William Oughired – A Great 17th Century Teacher of Mathematics (Chicago: Open Court Publishing company 1916: pp. 88).

- Rene Descartes



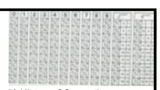
The Gelosia Method Of Multiplication

- Probable origins (Williams): India and later Arab, Persian, Chinese societies by the Middle Ages.



http://www.history.org.uk

Napier's Bones

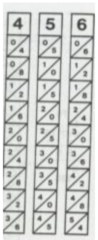


"A History of Computing Technology" by Williams

- John Napier was born in 1550 in Scotland (Williams)
- Best known for the invention of logarithms (Williams)
- Napier's bones :
  - Known by various names: Rabdologia (after book title), numbering rods
  - Constructed of bone-like material (ivory, horns, actual bones)
  - …which is perhaps why the name 'bones' "…just refused to die out." (Williams p. 84)
  - Used to perform multiplications and calculate logarithms

Napier's Bones: Multiplication

- A collection of all possible columns of the Gelosia table

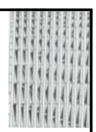


Images from "A History of Computing Technology" by Williams

External Extra Video: Napier's Bones

- Jane Wess from the Science Museum: how to use the bones.
  - https://www.youtube.com/watch?v=1nWT-zbb3s8

Genaille-Lucas Rulers

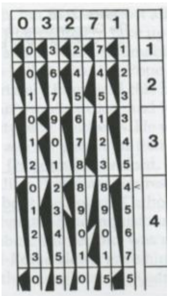


"A History of Computing Technology" by Williams

- Brief background:
  - Henri Genaille: worked as a civil engineer for a railway
  - Edouard Lucas: a French mathematician
- Their ruler
  - Similar to the Napier Bones but didn't require the operator to remember the carry
  - Each column represents a digit.
  - Rearrange the individual columns in order to determine the result of a multiplication
  - Starting at the appropriate row (row = one operand in the multiplication) in the last column find the first digit of the product (first digit in that row).
  - Working left, follow the arrows to the next digit of the product under the entire product has been calculated.

Genaille-Lucas Rulers : Multiplication Example

- From Williams pp. 95: 3271 * 4 = 13084



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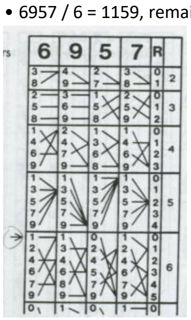
Genaille-Lucas Rulers: Division Example

- 6957 / 6 = 1159, remainder = 3



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"A History of Computing Technology" by Williams

Video: Genaille-Lucas Rulers:

- James Tam from the University of Calgary:
  - https://youtu.be/8CoNctAjQY0?list=PLTma1no4UaZvK12abFsZBOYX0gWgVyNU4

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Logarithms

- John Napier has always been given credit because, "…other developments [by other people] were either left unpublished or, in some cases, not recognized for what they were at the time". (Williams).
  - (Review):
  - Logarithm of a number ('technical explanation'): the exponent that the base has to be raised in order to produce that number.
  - Logarithm of a number (lay explanation): "*How many of one number do we multiply to get another number?" – mathisfun.com*
  - Example: $\log_2(16) = 4$ (or 2 has to raised to the 4th power to produce 16).

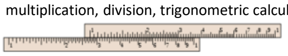
Logarithms: Application

- Logarithmic tables have been used to simplify complex calculations

Geometric sequence (double)	1	2	4	8	16	32	64	128	256
Arithmetic sequence (log)	0	1	2	3	4	5	6	7	8

Slide Rulers

- Slide rules were simply mechanical implementations of the logarithmic tables.
  - Many people developed their own version of a slide ruler:
  - Edmund Gunter: "Line of Numbers"
    - William Oughtred (pure mathematician not "doer of tricks"/calculating instruments) and his pupils:
      - Richard Delamain: described a circular slide rule in a book called "Grammelogia" (the name of his 'slide rule')…could be used on horseback as well as it could be used on foot!
      - William Forster: collaborated and helped push Oughtred to publish works on his 'slide rule'
  - Slide rules could be used to perform many mathematical operations: multiplication, division, trigonometric calculations, roots and powers.



Division operation: Image from Wikipedia

William Oughtred

- 1574? – 1660
- One of the leading mathematicians of his time
  - Willing to teach for free
  - Focused on his work (Sleeping? Eating? Who needs them!)
- Clergyman or mathematician?

James Tam

'Modern' Slide Ruler

Colourbox.com

- Invented in 1850 by a 19 year old French artillery officer Amedee Mannheim
  - The moveable cursor was actually used in a slide rule designed 200 years earlier for the British navy but it was ignored and forgotten until 'invented' by Mannheim (Williams)

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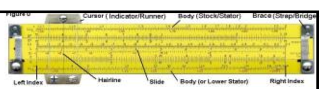
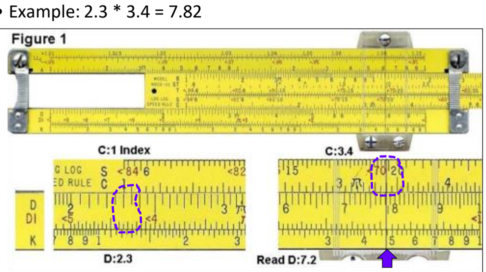
Modern Slide Rule: Multiplication



- Example: 2.3 * 3.4 = 7.82



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Images from 'The slide rule museum'

After This Session You Should Now Know

- Approximate dates and timelines
- How to perform simple multiplication using the finger reckoning system show in class
  - Results from 5 times 6 up to 10 times 10
  - Intermediate results must also be known
- How to represent any valid quantity using three different methods of counting using fingers.
- The abacus
  - How to represent different quantities using the two abaci shown in class.
  - The influence of the abacus on language
  - Representing different quantities using the table abacus (lines and spaces)

James Tam

After This Section You Should Now Know (2)

- Astrolabes
  - Some of the common uses
  - The origins and it's approximate time period of invention
- Quadrant
  - Some of the common uses
  - The approximate time period of invention and use
- Proportional compass
  - How was one used
- Sector
  - Who was widely attributed as the creator
  - How one was used in artillery calculations
- How to perform multiplications using the Gelosia method

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After This Section You Should Now Know (3)

- The way in which Napier's bones were used to perform calculations
- How to perform multiplication or division using Genaille–Lucas rulers
- Logarithms
  - The person given credit for their development
  - How logarithms can be used to solve complex calculations
- Slide rules
  - The mathematical functions that can be computed using a slide rule
  - Who was the person credited as inventing the modern slide rule
  - How the modern slide rule can complete calculations such as multiplication
  - The difference between the older and the modern slide rules

James Tam

References

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  - http://www.mhs.ox.ac.uk/epact/
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- Slide rule museum (last accessed November 9 2011)
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