Overview

In class

China

Problems from the Nine Chapters
Algorithm to compute square roots
Magic Squares

India

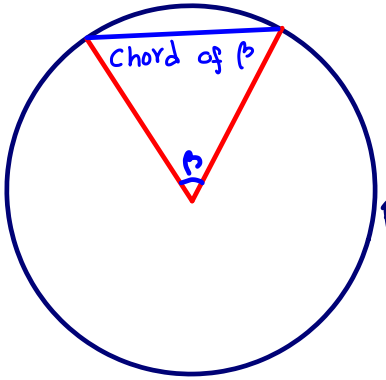
Trigonometry
"Fibonacci" numbers
Positional number system

Islamic World

Al-Khwarizmi
Roots of quadratic eq

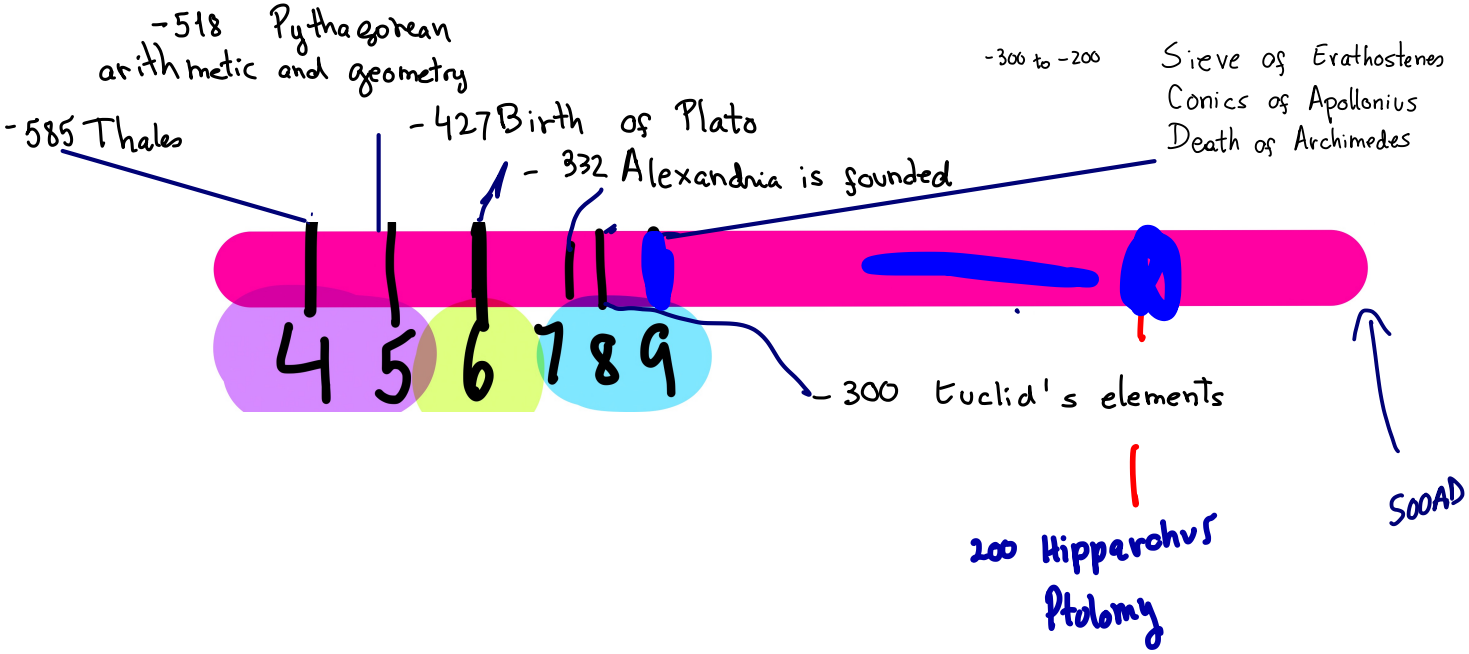
Greek mathematics

4. -585 Thales
5. -518 Pythagorean arithmetic and geometry
6. -427 Birth of Plato
7. -332 Alexandria is founded
8. -300 Euclid's elements
9. -300 to -200 Sieve of Erathostenes
   Conics of Apollonius
   Death of Archimedes



Hipparchus de Rhodes (Greek astronomer 2nd century BCE)
- Represented the sky as a giant sphere
- Position of stars given by the angles
- Used chords to compute positions

Ptolomy (Greek astronomer 2nd century AD)
- wrote the Almagest, including a theory of chords
- study of spherical triangles.
- Computed a table of approximations to chords



1. -2400 Positional number system
2. -1850 Moscow Papyrus
3. -1650 Rhind Papirus
4. -585 Thales
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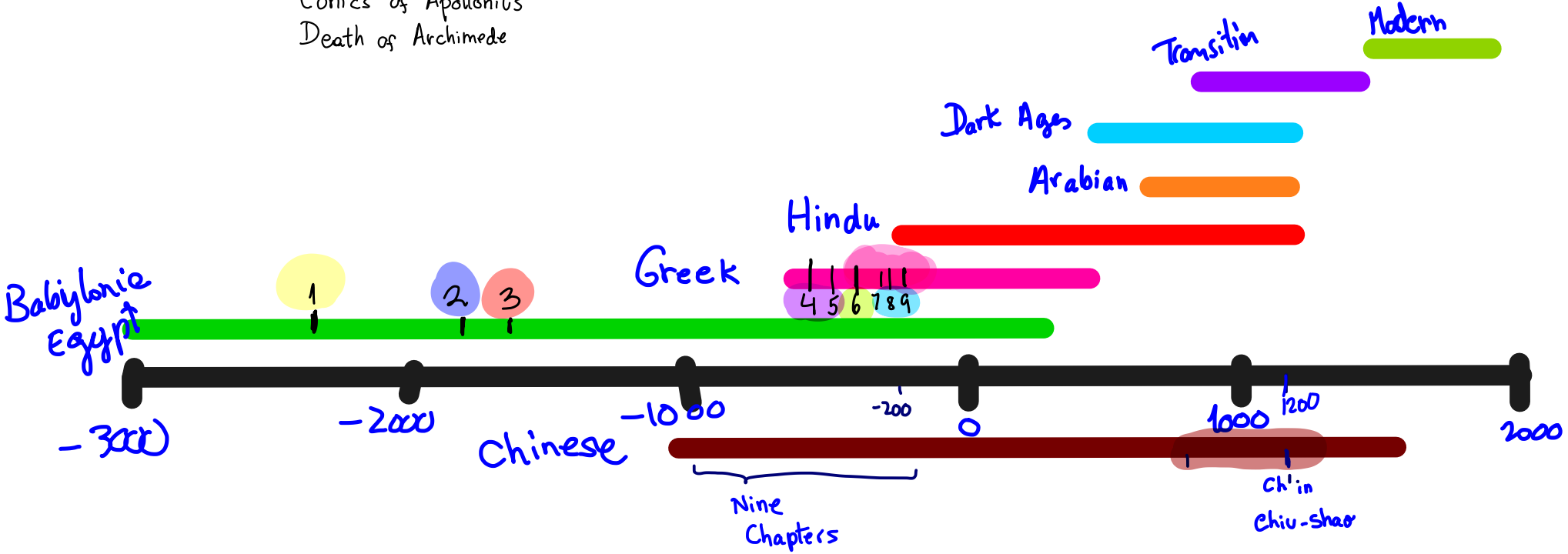
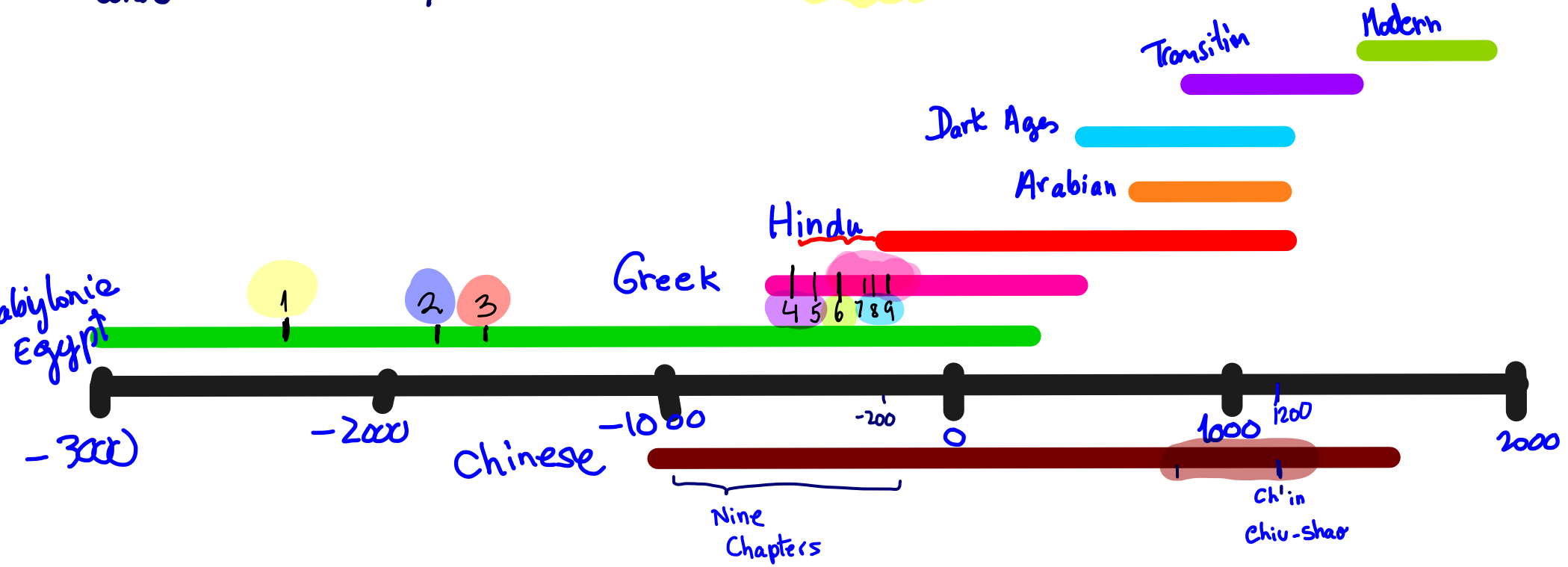


- 5th century AD → end of Greek mathematical tradition in classical form
- 5th to 8th century ⇝ Not much math activity in Western Europe
  North Africa
  Middle East
  → Roman Empire
  → However, math life goes on.

8th century
Part of Europe
North Africa
Part of Middle East
conquered by Islamic forces

While the Islamic Empire settle down ⇝ India math tradition flourished



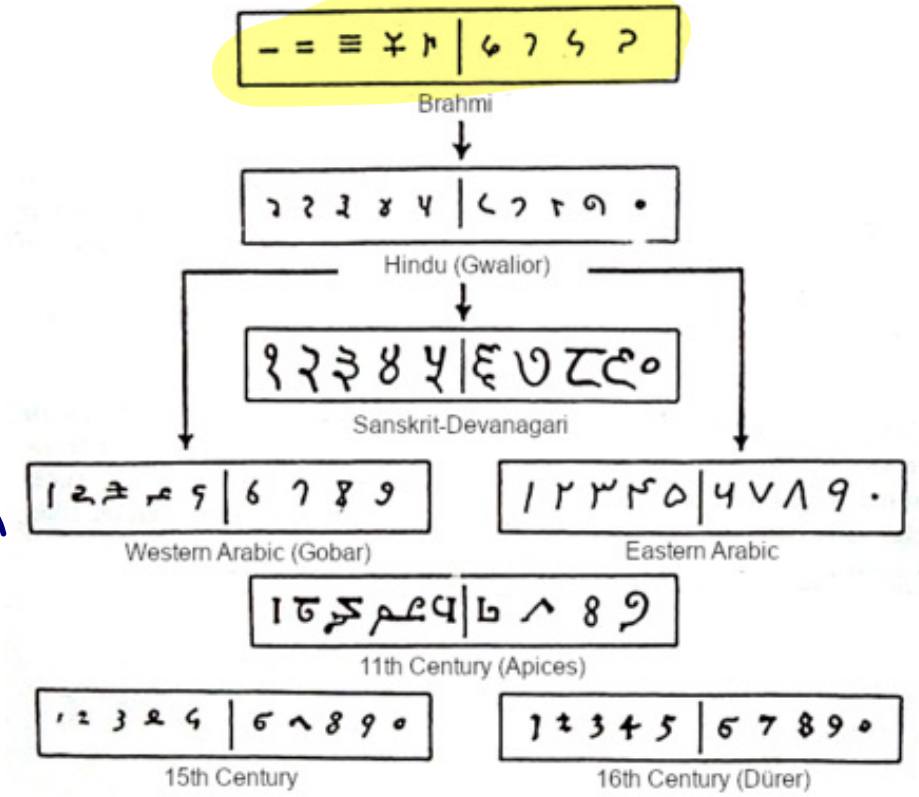
Decimal Positional Number System

Ancient Indian Mathematics

Ancient Indian Mathematics:

Positional Number system

- Astronomy motivated the study of mathematics
- Earliest texts are written in Sanskrit verse (!)
  - A tradition of commentaries surfaced.
- Important names
  - Āryabhata — 6th century
  - Brahmagupta, Bhās Kara — 7th century — Negative numbers
  - Bhāskara II — 12th century
- Decimal positional number system
  - Digits 1, 2, 3, 4, 5, 6, 7, 8, 9 and 0
  - Influence from China?
  - Fast spread to other cultures
    - Example Syria 6th century mentioned this fast method of computation
    - 9th century: known in Baghdad
      - transmited to Europe



Development of Hindu–Arabic numerals - Wikipedia
is

Virañhka numbers

Ancient Indian Mathematics

Virahnka-numbers

↓ between 600 and 900, India

Basic unit in Sanskrit poetry: syllables – short → 1 beat 1
or
long → 2 beats S

beats	# of Rhythms
1	1
2	2
3	3
4	5
5	8
6	13

Fibonacc

1

11 S

111, S1, 1S

1111, 11S, S11, 1S1, SS

Virahnka-Fibonacci numbers

between 600 and 900, India

1100, Italy

Basic unit in Sanskrit poetry: syllables – short → 1 beat I
or
long → 2 beats S

Let's twik this setting.
Assume now that short "I" means 1 syllable
long S means two syllables

Write down a verse for each rhythm of

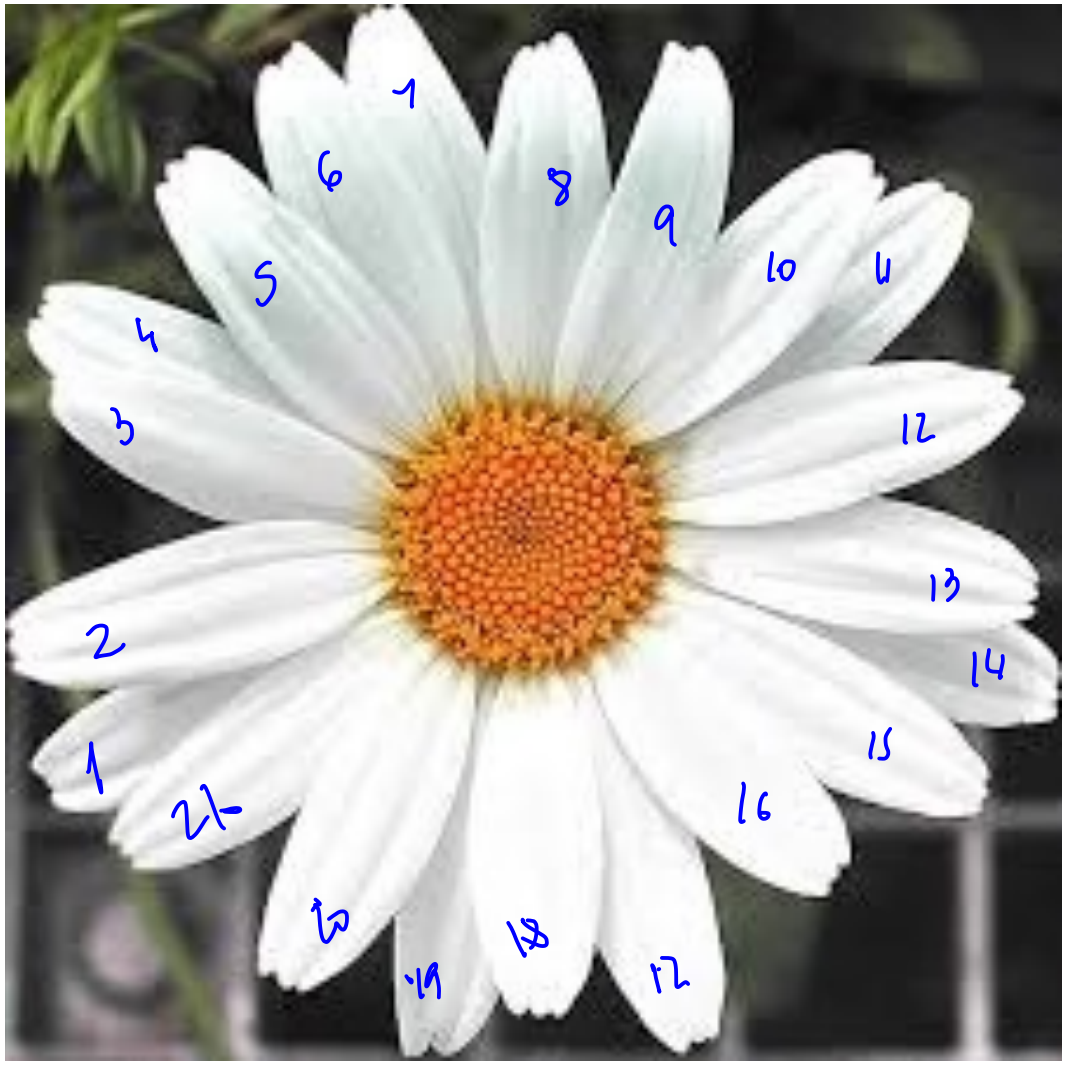
1,2,3,4... syllables

1 Words of a
2 syllables.
3
4 III I do not!

Example

III
SI
IS

IS I forgive




1
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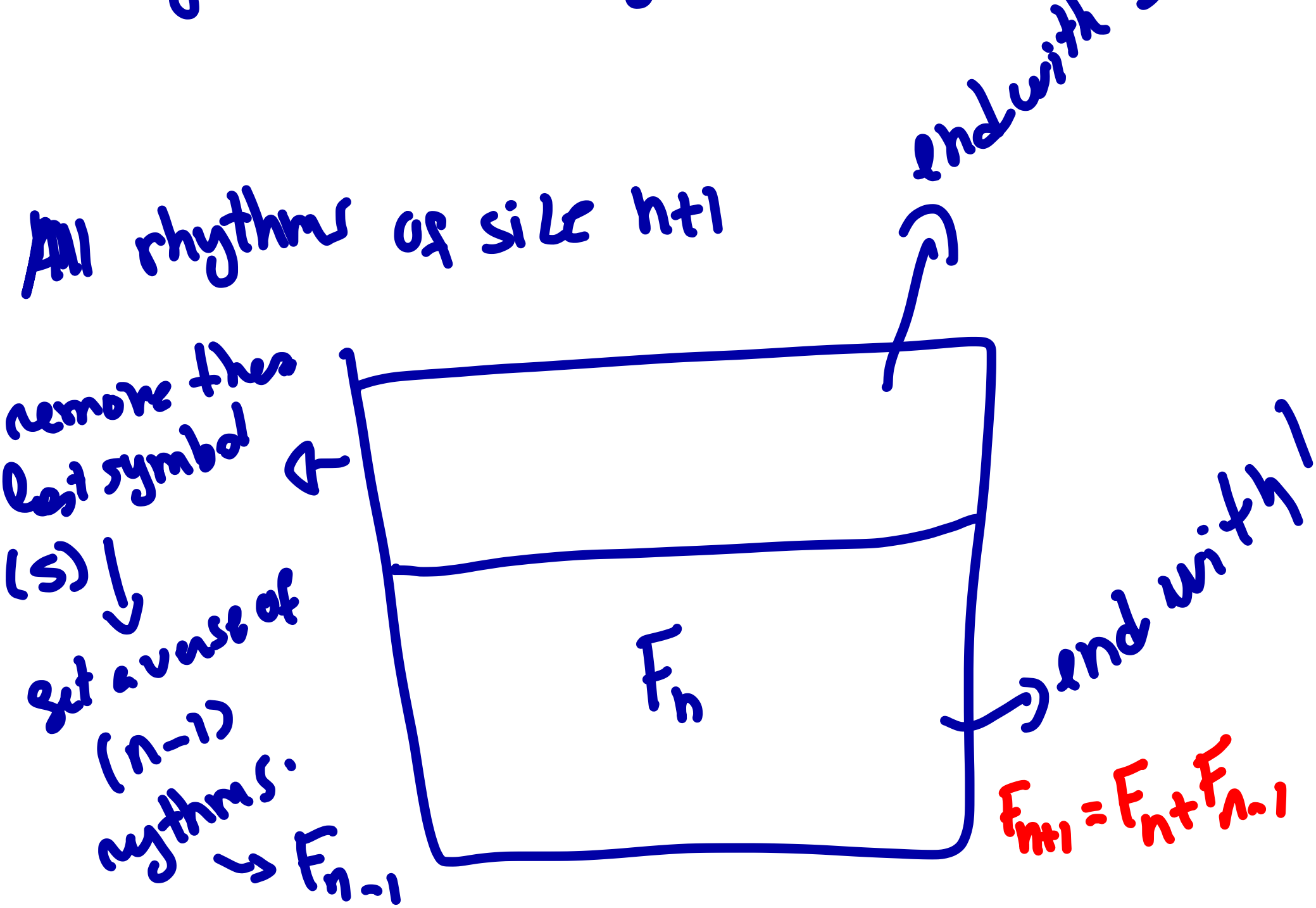
34

Homework Problem 3

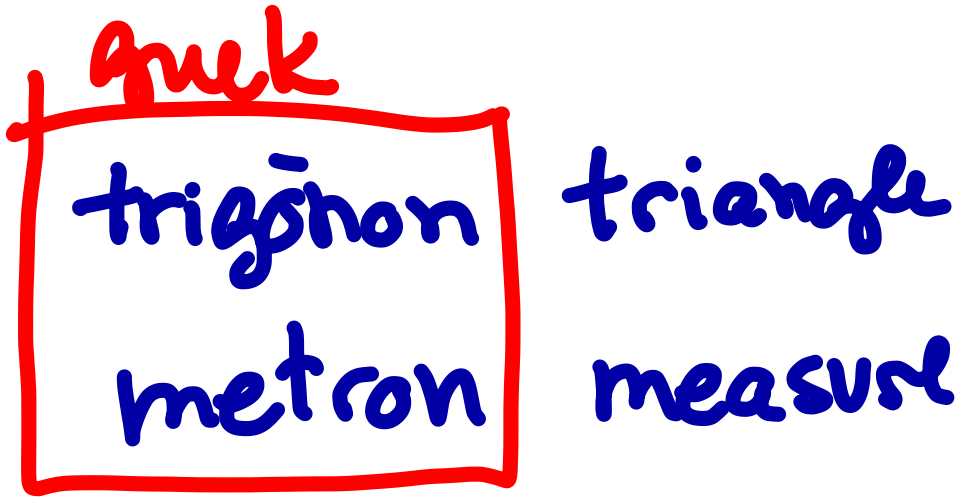
Describe the relationship between the spiral of pinaples and the Fibonacci (virahnka) numbers.

1 syl. → 1 rhythm.

All rhythms of size n+1



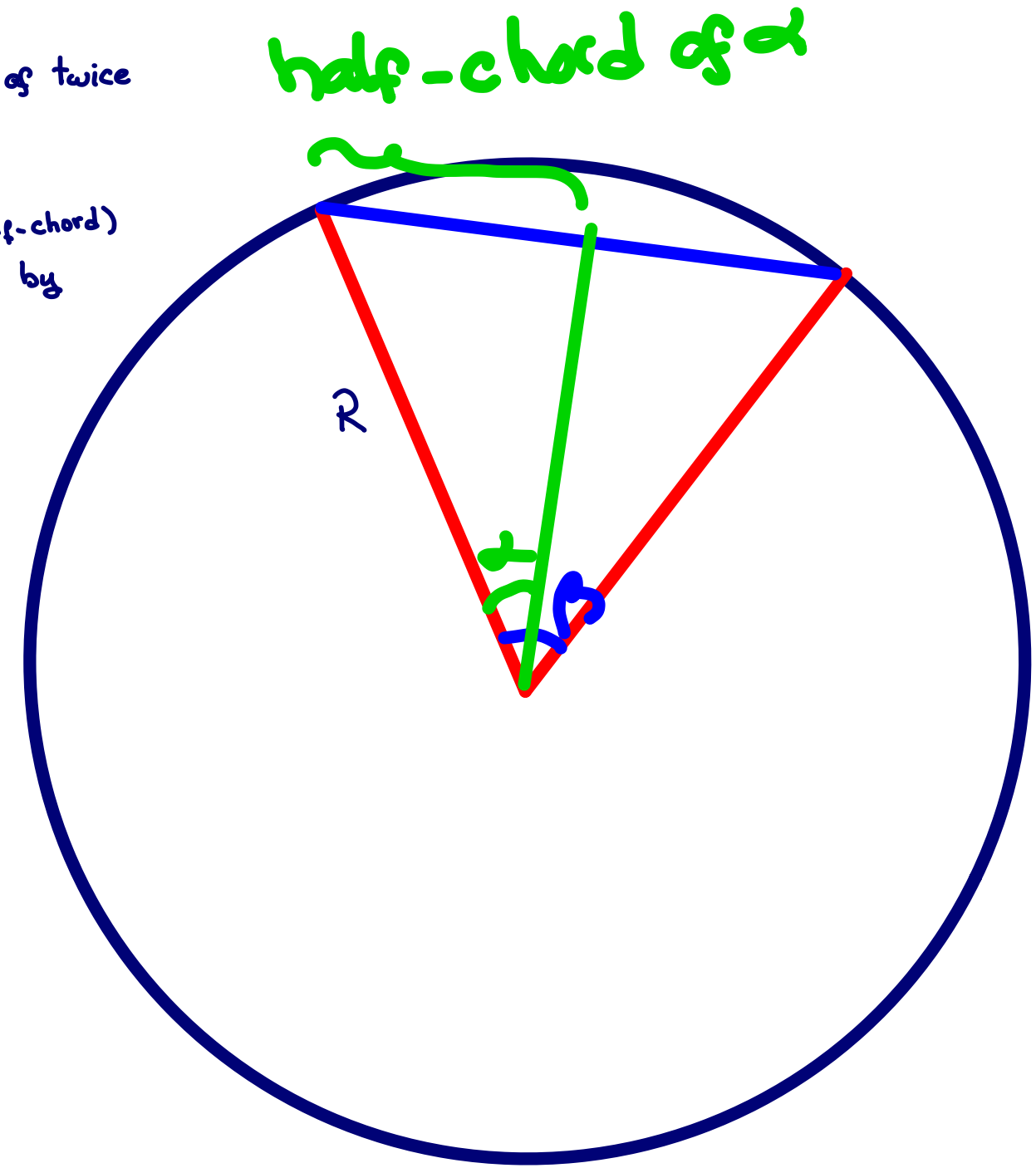
Ancient Indian Trigonometry



Ancient Indian Mathematics

Indian mathematicians used half the chord of twice the angle. $\frac{1}{2}\text{chord}(2\alpha)$

Aryabhata wrote "jya" (for "ardha-jya", half-chord)
This was phonetically translated to "jiba" by Arab mathematicians, and written "jb".
The closest real Arab word was "jaib";
which means "bay."
The Latin word for "bay" is...



$$\sin\alpha = \frac{\frac{1}{2}\text{chord}(2\alpha)}{R}$$

India

Aryabhata (Indian astronomer, 5th century AD)

मखि भखि फखि धखि णखि ञखि
ञखि हसझ स्कचि किग्ष घखि घ्वच ।
घ्लकि किग्र हक्य धकि किच
स्ग श्झ ञ्व क्ल प्त फ छ कलार्धज्याः ॥

makhi bhakhi phakhi dhakhi ṇakhi ñakhi
ñakhi hasjha skaki kiṣga ghakhi kighva ।
ghlaki kigra hakya dhaki kica
sga śjha ṅva kla pta pha cha
kala-ardha- jyāḥ ॥

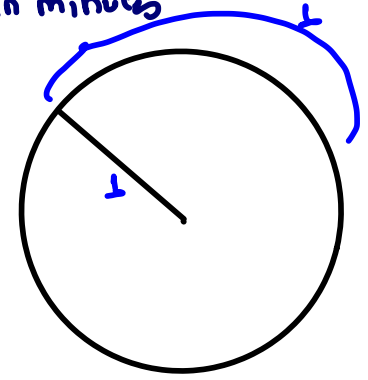
The sanscrit verse

contains an encoded table of sines correct up to 3 decimal places.

The code is explained by Aryabhata.

Angles are measured in minutes, from 0 to 5400.

Sines are measured in minutes



$2\pi - 360 \times 60$

$1 - \frac{360}{2\pi} \times 60 \sim 3438$

ka=1	kha=2	ga=3
ca=6	cha=7	ja=8
.ta=11	.tha=12	.da=13
ta=16	tha=17	da=18
pa=21	pha=22	ba=23
gha=4	"na=5	
jha=9	~na=10	
dha=14	.na=15	
dha=19	na=20	
bha=24	ma=25	

ya=30	ra=40
la=50	va=60
"sa=70	.sa=80
sa=90	ha=100

a=1	i=100	u=100^2
.r=100^3	.l=100^4	
e=100^5	ai=100^6	
o=100^7	au=100^8	

			angle in minutes	sine from verse	sine/ 3438	sine from calculator
			0	0	0	0
makhi	225	khi=200 ma=25	225	225	0.0654	0.0654
bhakhi	224	khi=200 bha=24	450	449	0.1306	0.1305
phakhi	222	khi=200 pha=22	675	671	0.1952	0.1951
dhakhi	219	khi=200 dha=19	900	890	0.2589	0.2588
.nakhi	215	khi=200 .na=15	1125	1105	0.3214	0.3214
~nakhi	210	khi=200 ~na=10	1350	1315	0.3825	0.3827
"nakhi	205	khi=200 "na=5	1575	1520	0.4421	0.4423
hasjha	199	ha=100 sa=90 jha=9	1800	1719	0.5	0.5
skaki	191	ki=100 sa=90 ka=1	2025	1910	0.5556	0.5556
ki.sga	183	ki=100 .sa=80 ga=3	2250	2093	0.6088	0.6088
"sghaki	174	ki=100 "sa=70 gha=4	2425	2267	0.6594	0.6593
kighva	164	ki=100 va=60 gha=4	2700	2431	0.7071	0.7071
ghlaki	154	ki=100 gha=4 la=50	2925	2585	0.7519	0.7518
kigra	143	ki=100 ra=40 ga=3	3150	2728	0.7935	0.7934
hakya	131	ha=100 ya=30 ka=1	3375	2859	0.8316	0.8315
dhaki	119	dha=19 ki=ka+i=100	3600	2978	0.8662	0.8660
kica	106	ka=1 i=100 ca=6	3825	3084	0.8970	0.8969
sga	93	sa=90 ga=3	4050	3177	0.9241	0.9239
"sjha	79	"sa=70 jha=9	4275	3256	0.9471	0.9469
"nva	65	"na=5 va=60	4500	3321	0.9660	0.9659
kla	51	ka=1 la=50	4725	3372	0.9808	0.9808
pta	37	pa=21 ta=16	4950	3409	0.9916	0.9914
pha	22		5175	3431	0.9980	0.9979
cha	7		5400	3438	1.	1.

Source: Sines in terse verse
by Roddam Narasimha

https://www.nature.com/articles/414851a3

See also Prof Phillips column:

http://www.math.stonybrook.edu/~tony/whatsnew/jun02/06-2002-media.html#sanscriti