## Go forth, and Multiply!

Maths Club

Elliott Tjia

Maths Club Go forth, and Multiply!

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What is a number base?

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- What is a number base?
- What is our main number base?

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- What is a number base?
- What is our main number base?
  - ► Ten (Decimal)
  - Digits used: 0,1,2,3,4,5,6,7,8,9

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- What is a number base?
- What is our main number base?
  - ► Ten (Decimal)
  - Digits used: 0,1,2,3,4,5,6,7,8,9
- A number base is just a representation of the same information, and doesn't change the data itself.

### One, Two, Many, Many-One,...

How did people count?

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## One, Two, Many, Many-One,...

- How did people count?
  - Babylonians, base 60 counting system.
  - Mayans, base 20 today is 13.0.0.3.4

<b>7</b> 1	<b>₹7</b> 11	<b>∜7</b> 21	<b>***7</b> 31	<b>41</b> 41	<b>**</b> 7 51
<b>77</b> 2	<b>477</b> 12	<b>₹{??</b> 22	<b>***(17</b> 32	<b>4217</b> 42	<b>*** 17</b> 52
<b>ҮҮҮ</b> з	<b>₹₩</b> 13	<b>∜₩</b> 23	<b>***!???</b> 33	<b>43</b>	<b>5</b> 3
<b>97</b> 4	<b>₹\$\$</b> 14	<b>₩\$\$</b> 24	<b>*** 💱</b> 34	<b>44</b>	<b>*** 🛱 5</b> 4
<b>W</b> 5	<b>∜</b> ∰ 15	<b>₩</b> ₩ 25	₩₩ 35	₩ 45	<b>*** 🛱 5</b> 5
<b>6</b>	<b>∢∰</b> 16	<b>∜₩</b> 26	₩₩ 36	<b>46</b>	<b>******</b> 56
<b>8</b> 7	17	<b>****</b> 27	₩₩ 37	<b>47</b>	<b>**** 5</b> 7
8	18	<b>₩₩</b> 28	₩₩ 38	<b>48</b> 48	<b>* * * *</b> 58
<b># 9</b>	<b>∢∰</b> 19	<b>* # 2</b> 9	<b>***</b> 39	<b>49</b>	<b>***#</b> 59
<b>∢</b> 10	<b>{{</b> 20	₩ 30	<b>4</b> 0	<b>**</b> 50	

Do we use any non-base ten counting?

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# One, Two, Many, Many-One,...

- How did people count?
  - Babylonians, base 60 counting system.
  - Mayans, base 20 today is 13.0.0.3.4

<b>7</b> 1	<b>₹7</b> 11	<b>4(7</b> 21	<b>***7</b> 31	<b>41</b> 41	<b>***</b> 7 51
<b>77</b> 2	<b>12</b>	<b>477</b> 22	<b>***(17</b> 32	<b>4217</b> 42	<b>*** 17</b> 52
₩ з	<b>13</b>	<b>∜₩</b> 23	<b>***!???</b> 33	<b>43</b>	<b>44 111</b> 53
<b>87</b> 4	<b>₹27</b> 14	<b>₩\$\$7</b> 24	<b>*** 💱</b> 34	<b>44</b>	<b>* * * *</b> 54
<b>¥</b> 5	15	<b>₩</b> ₩ 25	₩₩ 35	₩ 45	€€ 🛱 55
<b>6</b>	<b>16</b>	<b>∜₩</b> 26	₩₩ 36	<b>46</b>	<b>**** 75</b> 6
<b>7</b>	17	<b>₩₩</b> 27	₩₩ 37	<b>47</b>	<b>* * * *</b> 57
₩ 8	18	<b>₩₩</b> 28	₩₩ 38	<b>48</b> 48	<b>**** 5</b> 8
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<b>∢</b> 10	<b>{{</b> 20	₩ 30	<b>4</b> 0	<b>**</b> 50	

Do we use any non-base ten counting?

Seconds in a minute, minutes in an hour, hours in a day

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### An On-off relationship with computers

How to Computers count?

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# An On-off relationship with computers

- How to Computers count?
- Base 2 (Binary)

10001010101 001010111101010 01010100011010101010101 70707770777000707770007 101010111100010101001010101.01.1.1.1.0 707000707070707070707070707070 00001010110001010100100101011011 7000070707777070707070707 0777070707070007707070707 110001110001

Problem: Every base is base 10

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3 x 3

- Problem: Every base is base 10
- Notation for bases 345

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- Problem: Every base is base 10
- Notation for bases  $34_5 = 19_{10}$

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- Problem: Every base is base 10
- ▶ Notation for bases 34<sub>5</sub>= 19<sub>10</sub>= 10011<sub>2</sub>

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- Addition and subtraction still work in the same fashion
- ▶ 33<sub>7</sub> 12<sub>7</sub> =

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- Addition and subtraction still work in the same fashion
- ▶ 33<sub>7</sub> 12<sub>7</sub>=21<sub>7</sub>
- ▶  $23_5 + 14_5 =$

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- Addition and subtraction still work in the same fashion
- ▶ 33<sub>7</sub> 12<sub>7</sub>=21<sub>7</sub>
- $> 23_5 + 14_5 = 42_5$

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- Addition and subtraction still work in the same fashion
- ▶ 33<sub>7</sub> 12<sub>7</sub>=21<sub>7</sub>
- ▶  $23_5 + 14_5 = 42_5$
- Question Sheet 1

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- Hexadecimal is base 16
- ▶ 10<sub>10</sub> =??<sub>16</sub>

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- Hexadecimal is base 16
- ▶ 10<sub>10</sub> =??<sub>16</sub>
- Remembering that a base is defined by the number of unique digits used, base 16 can use the following digits: 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F

Conversion between bases is easier if one base is an integer power of the other e.g. 16 = 2<sup>4</sup>

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Conversion between bases is easier if one base is an integer power of the other e.g. 16 = 2<sup>4</sup>

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$$3_{16} = 11_2$$

•  $A_{16} = 1010_2$ 

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- Conversion between bases is easier if one base is an integer power of the other e.g. 16 = 2<sup>4</sup>
- ►  $3_{16} = 11_2$
- $A_{16} = 1010_2$
- ►  $3A_{16} = 111010_2$

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- Classical Algorithm
  - Napier's bones
- Single Digit Additions, Multiplications, Shifts.

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- In base 2, a multiplication by 2 is equivalent to a shift.
  - Peasant Multiplication

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- In base 2, a multiplication by 2 is equivalent to a shift.
  - Peasant Multiplication
- Karatsuba Algorithm

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- In base 2, a multiplication by 2 is equivalent to a shift.
  - Peasant Multiplication
- Karatsuba Algorithm
- Question Sheet 2

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- Base 8 is Octal
- Base 10 is Decimal

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- Base 8 is Octal
- Base 10 is Decimal
- OCT 31=

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- Base 8 is Octal
- Base 10 is Decimal
- OCT 31=DEC 25