



UC IRVINE MATH CEO

Community Educational Outreach



Meeting 14 Student's Booklet

AGES OF STORAGE

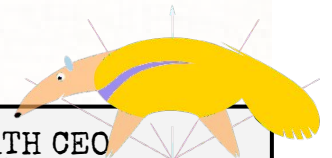
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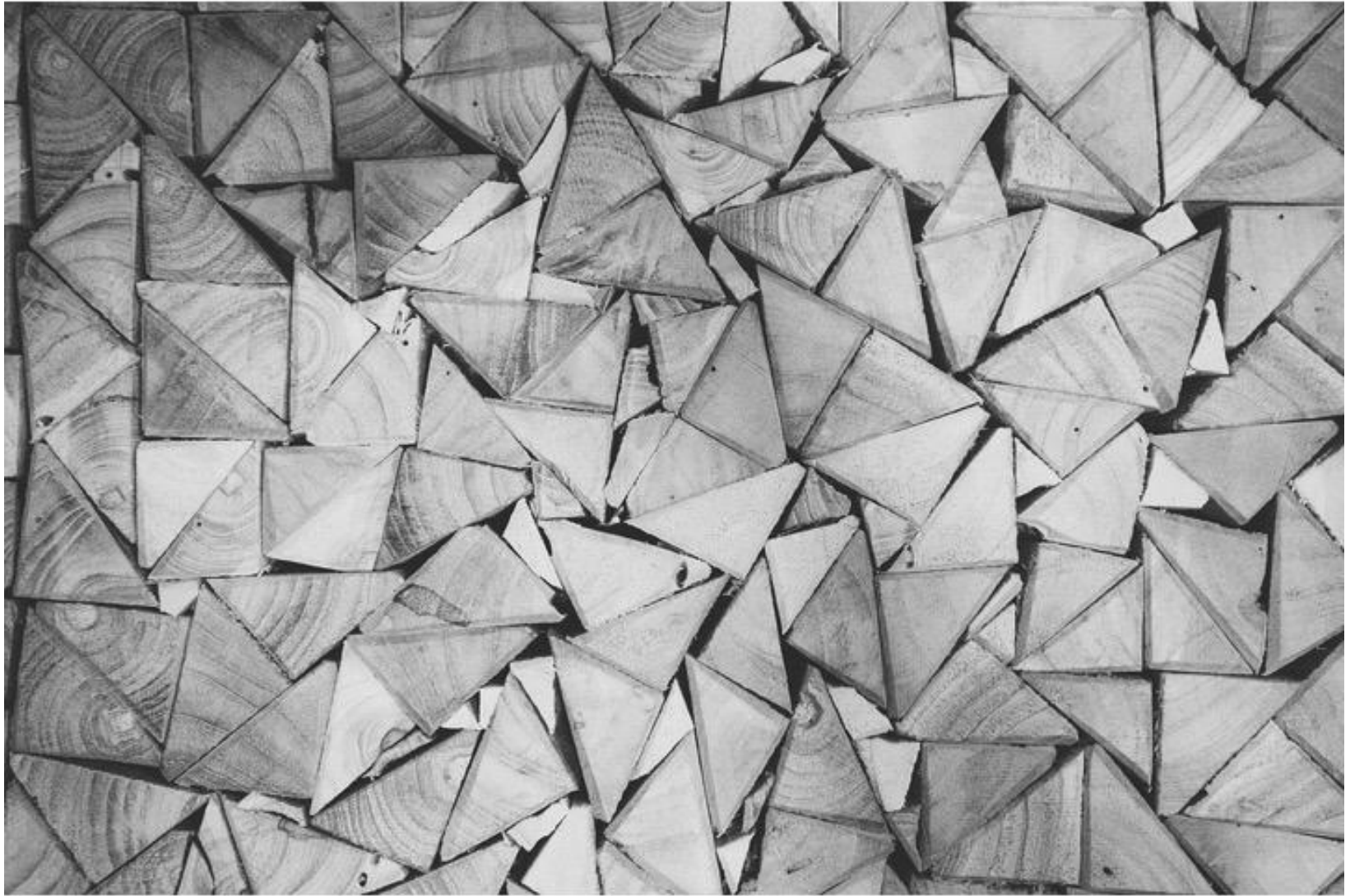
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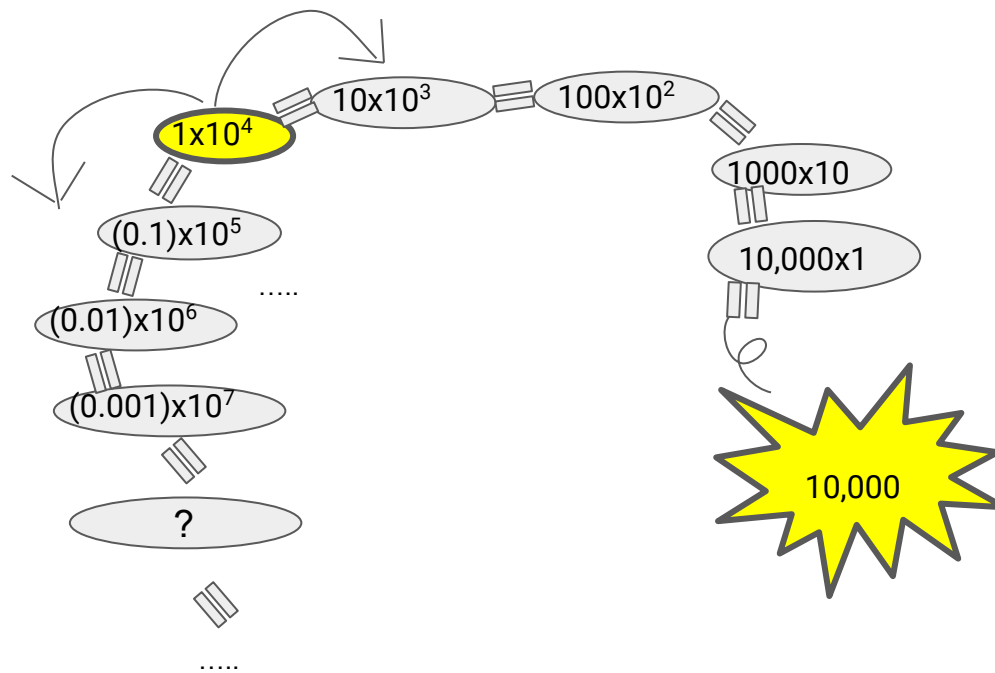
<http://www.math.uci.edu/mathceo/>







Different ways to write the same!!!



a Find **SIX** different ways to write 1,000 using powers of 10.

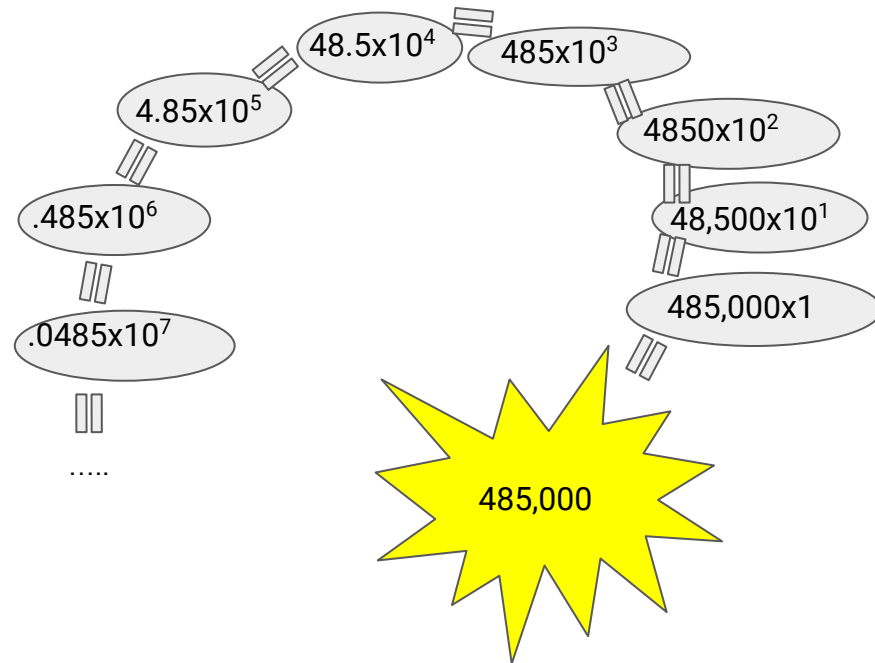
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This is cool.





Different ways to write the same!!!



b Find **SIX** different ways to write 4200 using powers of 10.

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This is cool.



Different ways to write the same!!!

We can organize powers of 10 in different groups...

$$1000,000,000 = \underbrace{10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10}_{9 \text{ times}} = 10^9$$

$$= \underbrace{10 \times 10 \times 10 \times 10 \times 10}_{5 \text{ times}} \times \underbrace{10 \times 10 \times 10 \times 10 \times 10}_{4 \text{ times}} = (10^4) \times (10^5) =$$

$$= \underbrace{10 \times 10}_{2 \text{ times}} \times \underbrace{10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10}_{7 \text{ times}} = (10^2) \times (10^7)$$

c Find **SIX** other ways to write the number 1000,000,000 using powers of 10.

Multiplying and Adding powers of 10

When we work with numbers, there are many ways we can rearrange them and they will mean the same. For example:

$$(4 \times 10^4) \times (5 \times 10^5) = (4)(5) \times 10^4 \times 10^5 = 20 \times 10^{4+5} = 20 \times 10^9$$

Do you notice how when multiplying we can switch their positions independently of their power of 10? What would you think would happen when we add two numbers with different powers of 10?

$$\begin{aligned}(2 \times 10^6) + (3 \times 10^5) &= (2 \times 10^{1+5}) + (3 \times 10^5) \\ &= (2 \times 10 \times 10^5) + (3 \times 10^5) \\ &= (20 \times 10^5) + (3 \times 10^5) \\ &= (20 + 3) \times 10^5 \\ &= 23 \times 10^5\end{aligned}$$

Let's practice now!!



Hands on Multiplying and Adding powers of 10

Match the elements from the left column with the proper element on the right column.

$(3 \times 10^4) + (7 \times 10^2)$



3×10^{11}

$(2 \times 10^{17}) + (4 \times 10^{15})$



54×10^{20}

$(5 \times 10^{11}) - (2 \times 10^{11})$



307×10^2

$(9 \times 10^8) (6 \times 10^{12})$



204×10^{15}



3



What is the closest number from above?

Many times it is not possible to have equalities but you can choose, from different numbers, the smallest number that is bigger to a number you will have at hand.

Example: For the number: $(3 \times 10^4) + (6 \times 10^2)$. What is the smallest number that is bigger than it from the following numbers?

$$21 \times 10^6$$

$$4 \times 10^4$$

$$10 \times 10^2$$

$$3 \times 10^2$$

First, we must notice that $(3 \times 10^4) + (6 \times 10^2) = 306 \times 10^2$ thus the closest number bigger than 306×10^2 is

$$4 \times 10^4$$

a

Let us practice now. Choose the smallest number that is bigger to $(8 \times 10^7) + (2 \times 10^6)$

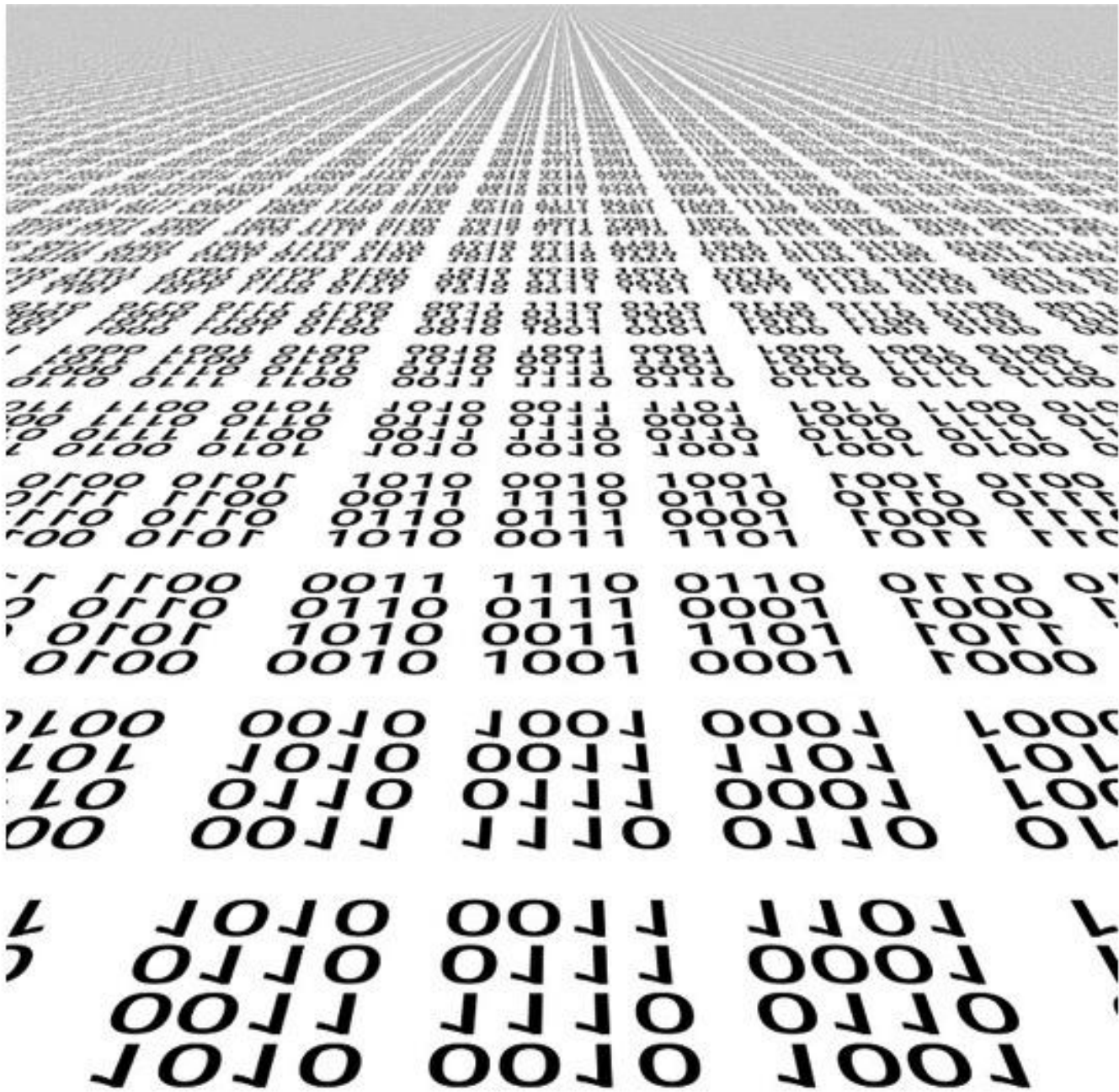
$$20 \times 10^6$$

$$9 \times 10^7$$

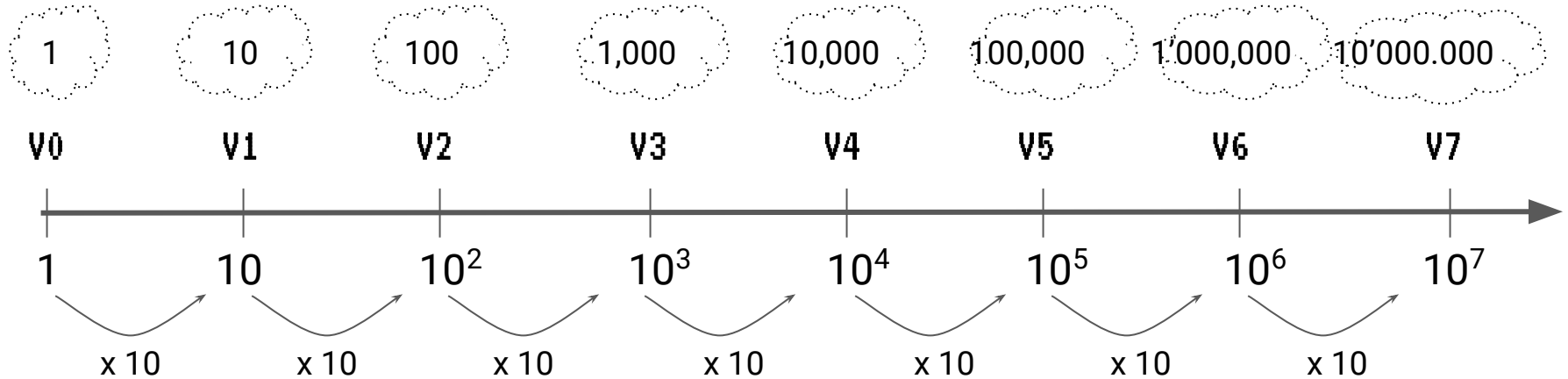
$$83 \times 10^5$$

$$45 \times 10^6$$





2 Tenplication

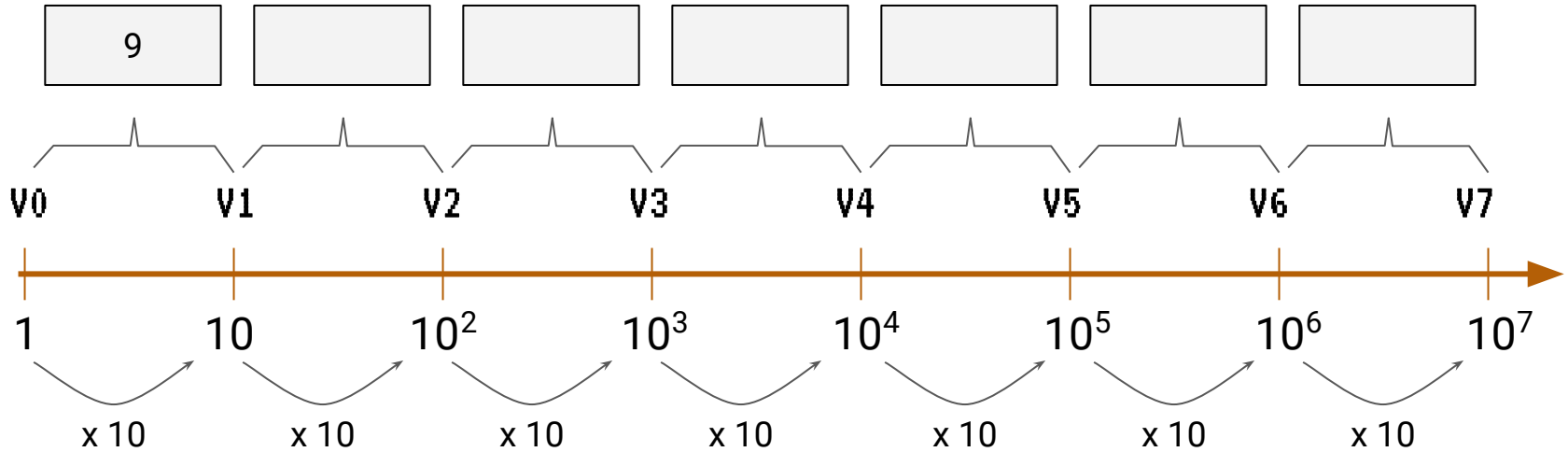


Decca Tech Computer Cloud had different versions. V0 (Version zero) is a cloud with a storage capacity of just one byte. Each new version of the cloud “**tenplicates**”: this means that the new cloud has a capacity equal to **ten times the capacity** of the previous cloud. For example, V2 cloud can store 10 times the capacity of V1, which in turn is 10 times the capacity of V0. Therefore V2’s capacity is: $10 \times 10 \times 1 = 10^2 = 100$ bytes.

a Match items on the left with item on the right having the same storage capacity:

- | | | | |
|------------------------|---|---|---------------|
| V4 | ● | ● | V7 |
| Ten times ten times V6 | ● | ● | A tenth of V2 |
| V1 | ● | ● | Ten times V3 |
| A thousand times V4 | ● | ● | V8 |

b Complete the blanks that indicate the difference in storage between consecutive versions.



Which pattern did you find in part b?

d What is the difference in storage between V_{14} and V_{11} ?

c What is the difference in storage between V_{13} and V_{11} ?
[Hint: what is the relation between V_{13} and V_{11} ?]

Pogo Server

Convention: represents _____ bytes.

e Pogo Server has three clouds: V3, V4 and V5, as indicated in the picture.

- V3 is 5/5 full.
- V4 is 2/5 full.
- V5 is 1/5 full.

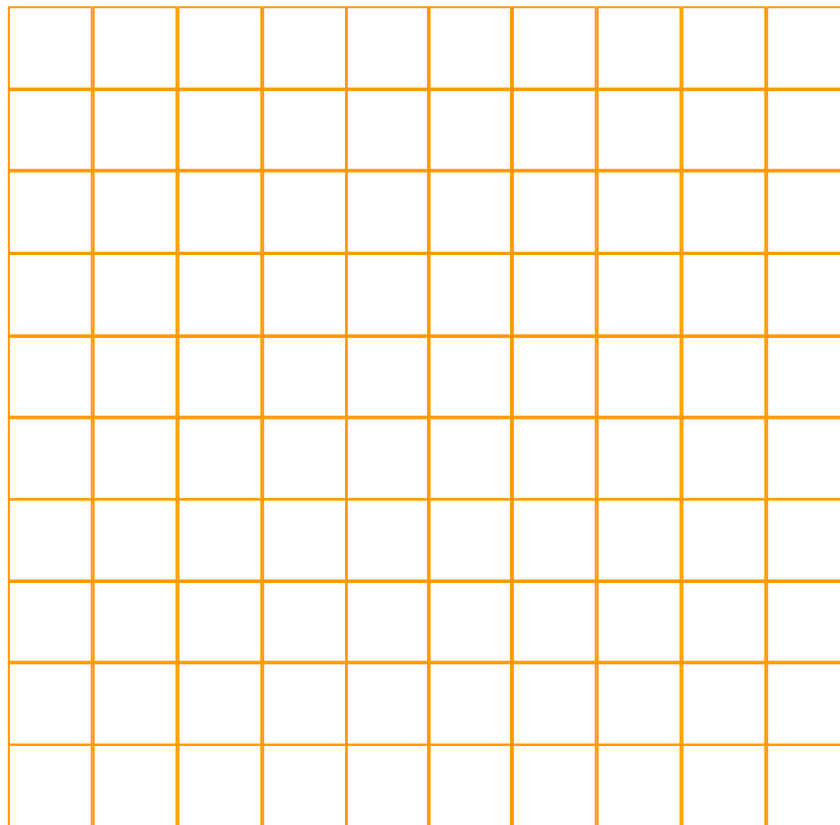
Indicate how many bytes each small square represents and shade the region corresponding to the used space of the server.

Find the remaining storage space of Pogo server.

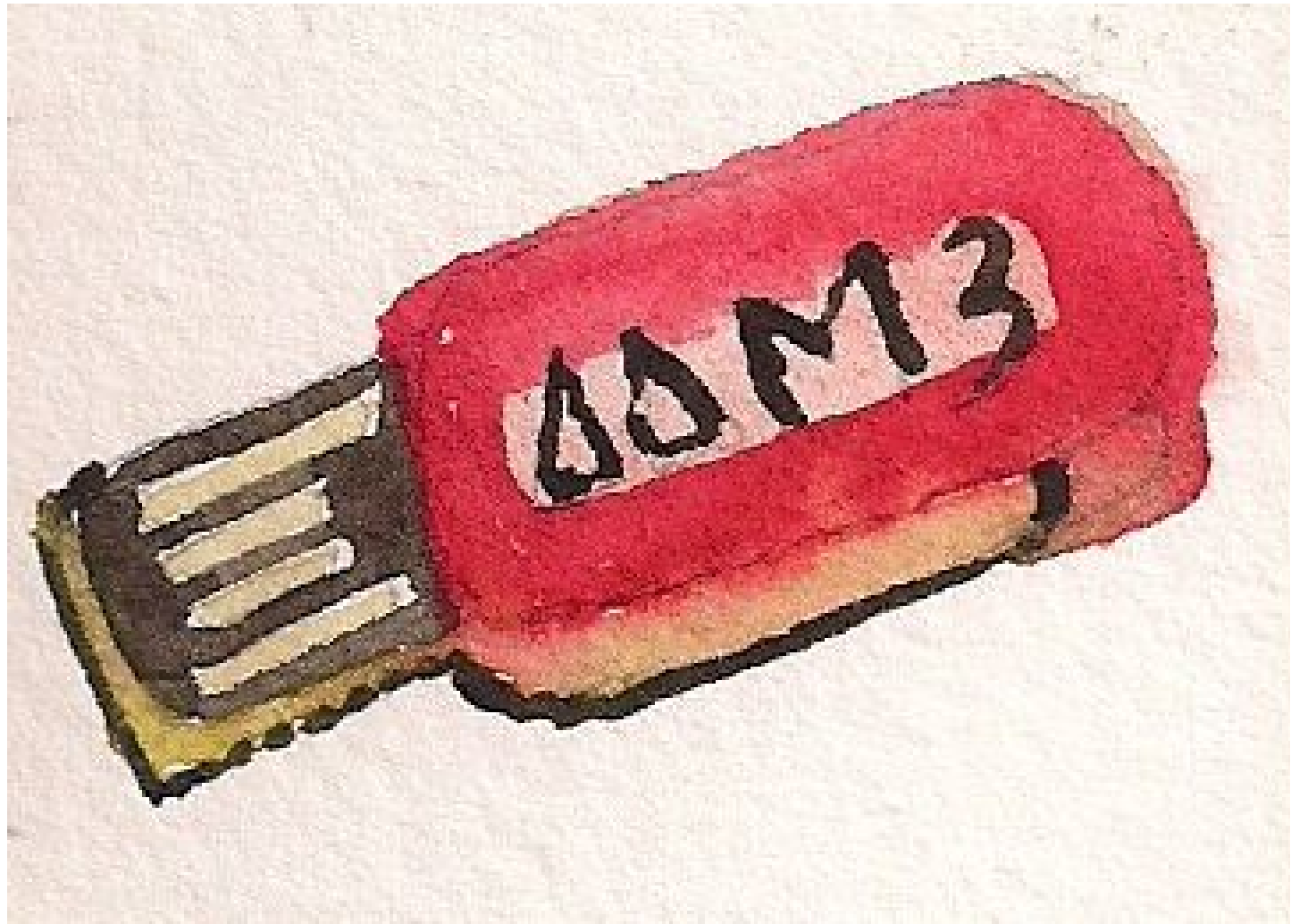
V3



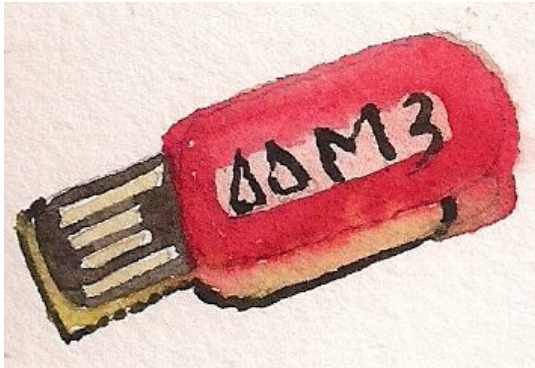
V4



V5



3 Flash Drives

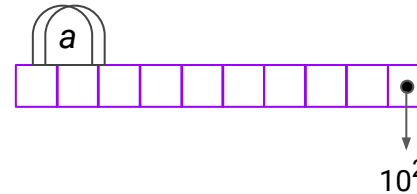


Flash drives are storage units which store data (in the form of bytes). Each byte can be thought as a letter.

The brand Chip Monkey develops flash drives. Each flash drive has:

- A **tag letter** to identify it.
- A **number of slots**, all having the same storage capacity in bytes.
- The **total capacity** of the flash drive is found by multiplying the slot capacity by the number of slots.

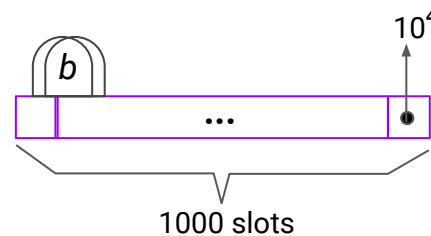
Here are some examples:



Memory a:

It has 10 slots, each holding 100 bytes.

Capacity: $10^1 \times 10^2 = 10^3$
(10,000) bytes.

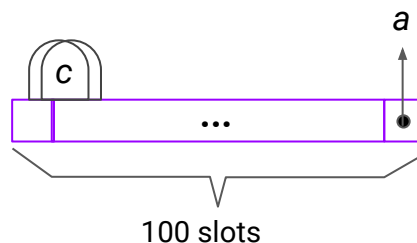


Memory b:

It has 10^4 slots, each holding 10^3 bytes.

Capacity: $10^4 \times 10^3 = 10^7$.
(10' 000,000) bytes

Sometimes a memory has the capacity of other smaller memories in each slot. An example:



Memory c:

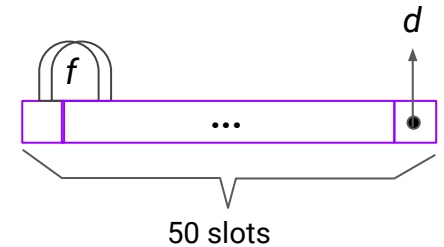
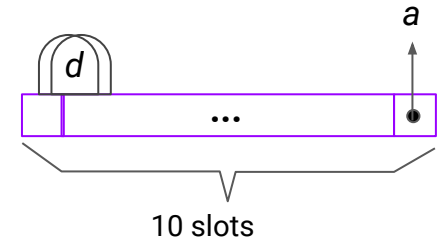
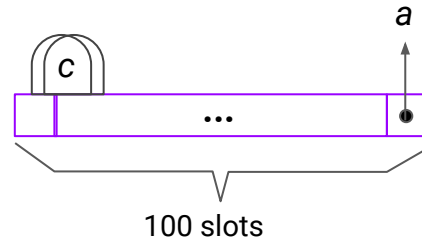
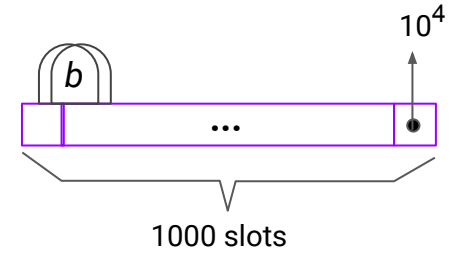
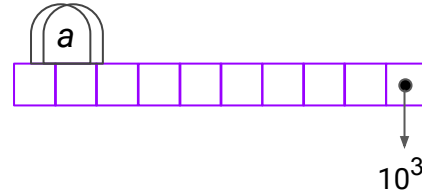
It has 100 slots, each of same storage as memory (a) (see example above).

Capacity: $100 \times 10^3 = 10^5$.
(100,000) bytes

A convenient storage

We want to use a flash drive that can store the following files:

- 1) One Book of 100,000 bytes
- 2) 100 Pictures of 10,000 bytes each
- 3) 10 songs of 10^5 bytes each



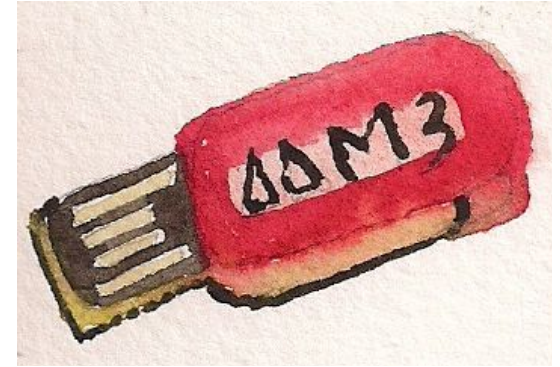
a We want to choose the smallest flash drive that can do the job, from memories a to f. Which one should we choose?

CHALLENGE: Maximizing storage

Flash drives are storage units which store data (in the form of bytes). Each byte can be thought as a letter.

The brand Chip Monkey develops flash drives. Each flash drive has:

- A **tag letter** to identify it.
- A **number of slots**, all having the same storage capacity in bytes.
- The **total capacity** of the flash drive is found by multiplying the slot capacity by the number of slots.



It is known that the smallest flash drive in the market able to store:

- 1) One Book of 100,000 bytes
- 2) 100 Pictures of 10,000 bytes each
- 3) 10 songs of 10^5 bytes each

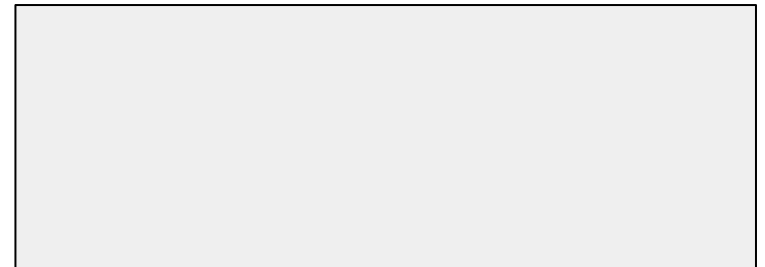
is a memory that has 30×10^5

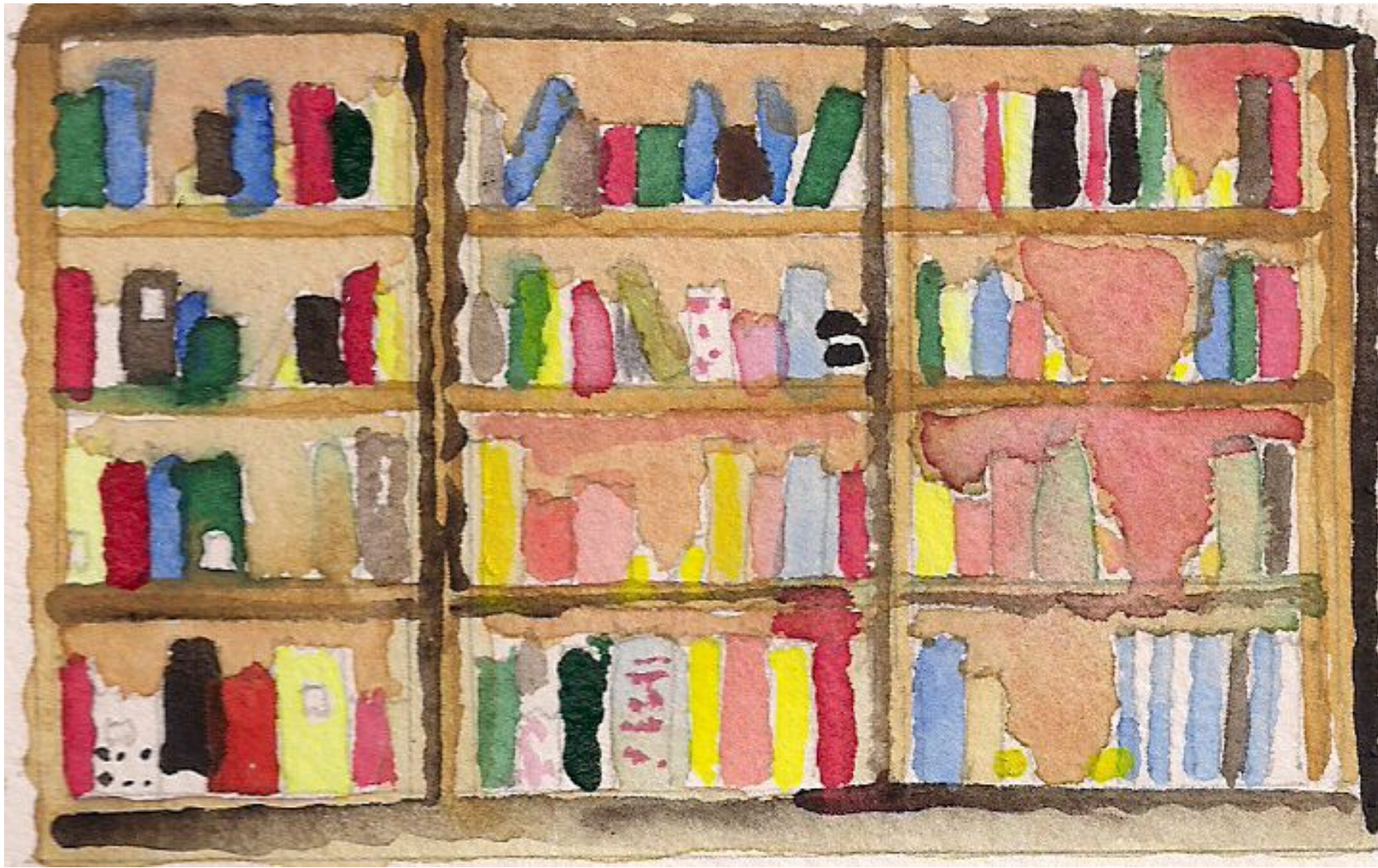
a

Create a flash drive spending the money however you want. Write down the storage obtained. Create as many flash drives as you want (or compare with other people's), looking for the best flash drive you can find.

We have a total of \$1'000.000 to build a model for a new flash drive. We can either

- Increase the number of slots by 1 by paying \$2;
- Increase the capacity of **all slots** by 1 byte, by paying \$1.





The universe (which others call the Library) is composed of an indefinite and perhaps infinite number of hexagonal galleries, with vast air shafts between, surrounded by very low railings. From any of the hexagons one can see, interminably, the upper and lower floors. The distribution of the galleries is invariable. Twenty shelves, five long shelves per side, cover all the sides except two; their height, which is the distance from floor to ceiling, scarcely exceeds that of a normal bookcase. One of the free sides leads to a narrow hallway which opens onto another gallery, identical to the first and to all the rest. To the left and right of the hallway there are two very small closets. In the first, one may sleep standing up; in the other, satisfy one's fecal necessities. Also through here passes a spiral stairway, which sinks abysmally and soars upwards to remote distances. In the hallway there is a mirror which faithfully duplicates all appearances. Men usually infer from this mirror that the Library is not infinite (if it were, why this illusory duplication?); I prefer to dream that its polished surfaces represent and promise the infinite ... Light is provided by some spherical fruit which bear the name of lamps. There are two, transversally placed, in each hexagon. The light they emit is insufficient, incessant...

(Taken from The Library of Babel, by Jorge Luis Borges)

4 The Library of Babel



Babel's library is an infinite library that appears in a story of Argentine writer Jorge Luis Borges. It contains all books that you may think of!

An **hexagon** in Babel's Library holds lots of books:

- Each side of the hexagon has 5 shelves.
- Each shelf contains 32 books.
- Each book has 410 pages.
- Each page has 40 lines.
- Each line has 80 letters.

a What is (approximately) the total number of printed letters that we find in an hexagon?

- 10^8
 10^9
 1.2×10^9
 2×10^9
 10^{10}

Remember that...

The number 10^9 represents the multiplication of 10 with itself 9 times:

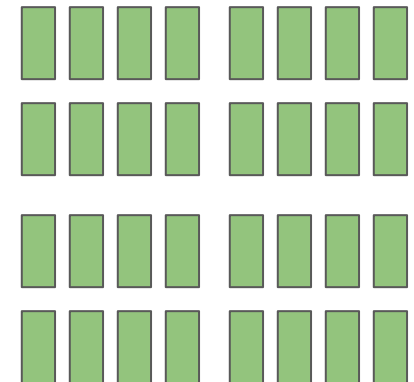
$$10^9 =$$

$$10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10 \times 10.$$

So: $10^9 = 1000'000,000$
(a thousand millions).

Example: there are 5.256×10^9 minutes in a lapse of 10,000 years!

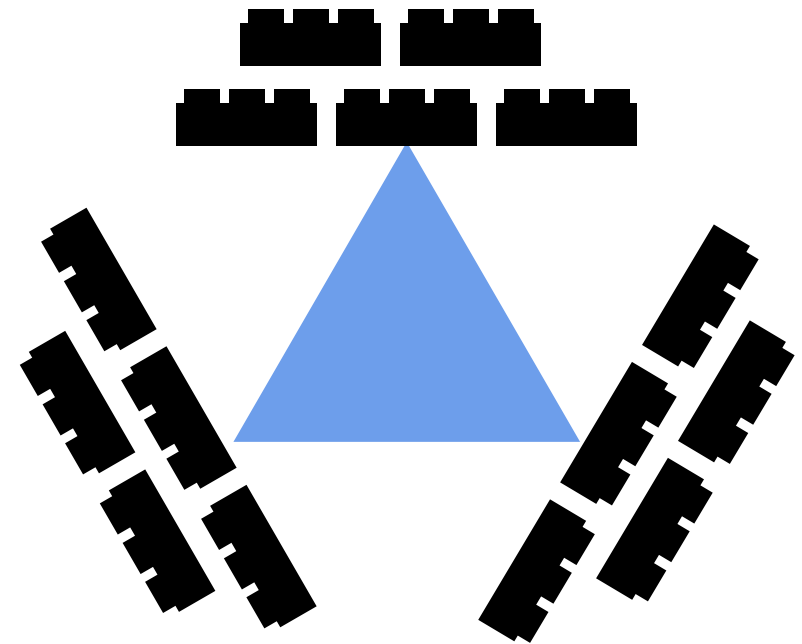
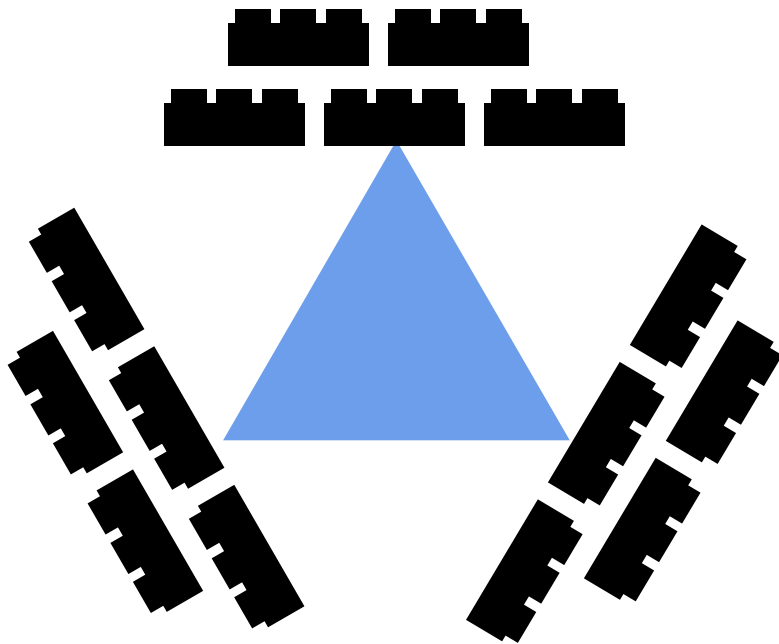
b If we remove 3/8 of the books in each shelf of the hexagon, approximately how many printed letters remain in the hexagon?



Section 6

In Section 6 of the library we find two triangular zones, each with 5 towers.

- Each tower has 32 floors.
- Each floor has 410 department.
- Each department has 40 rooms.
- Each room has 80 hexagons.



- C** Use your answer in (a) to estimate the total number of printed letters in Section 6.

CHALLENGE

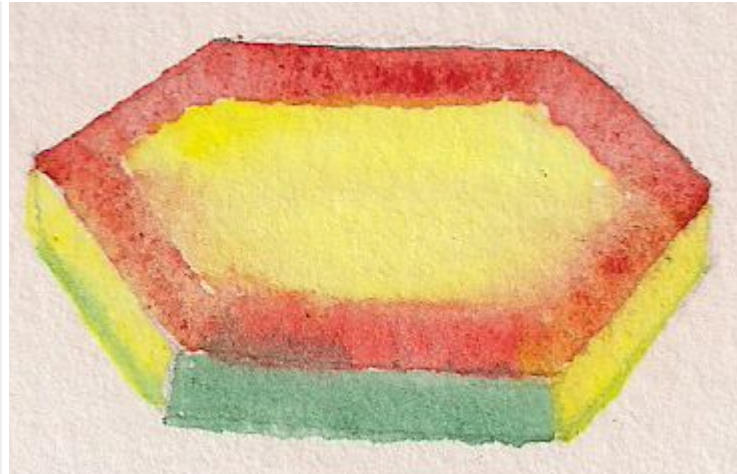
Remember that:

An **hexagon** in Babel's Library holds lots of books:

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In **Section 6** of the library we find two triangular zones, each with 5 towers.

- Each tower has 32 floors.
- Each floor has 410 zones.
- Each zone has 40 rooms.
- Each room has 80 hexagons.



Suppose that every second exactly one letter was written in a book of section 6.

How many years did it take to complete all books in Section 6?

