A ZERO COST LESSON PLAN

BINARY FOR THE YOUNGER SET

OR WHY COMPUTERS USE A “BINARY SYSTEM” TO DO WHAT THEY DO

TISP – Teachers In-Service Program

DRAFT 2015 12 14 by David Hepburn

QUESTION

- ASK EACH OTHER, HOW DID THE PEOPLE IN THE STONE AGE COUNT TIGERS, OR FISH, OR ENEMIES?

- ON THEIR FINGERS?
- WITH SMALL STONES? (Of course).
- STICKS?
- OR WHAT?

NEXT, LET' S CONSIDER….

- Today, we write all our letters starting on the left and moving to the right...
-
- --- THE CAT SAT ON THE MAT ---→

- But have you noticed that when we write numbers, we start on the RIGHT, and as they get bigger, we move over to the LEFT.

Notice:

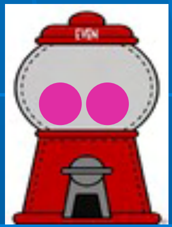
1
10
100
1000
10000

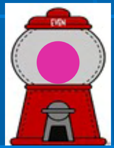
- Binary numbers work the same way.

What do you see here?

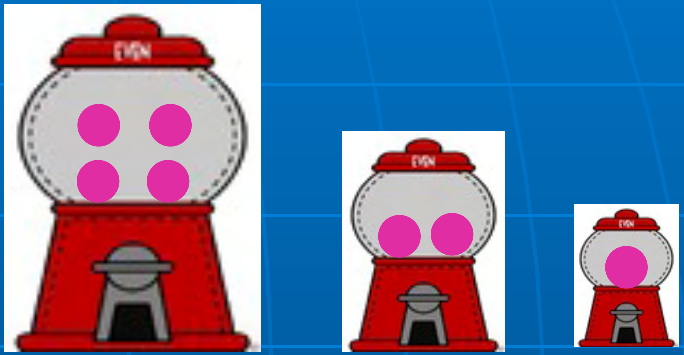
NOW…
VISUALIZE A ROW OF
5 GUMBALL MACHINES

- The one on the far right is very small and can only hold 1 gumball (max)

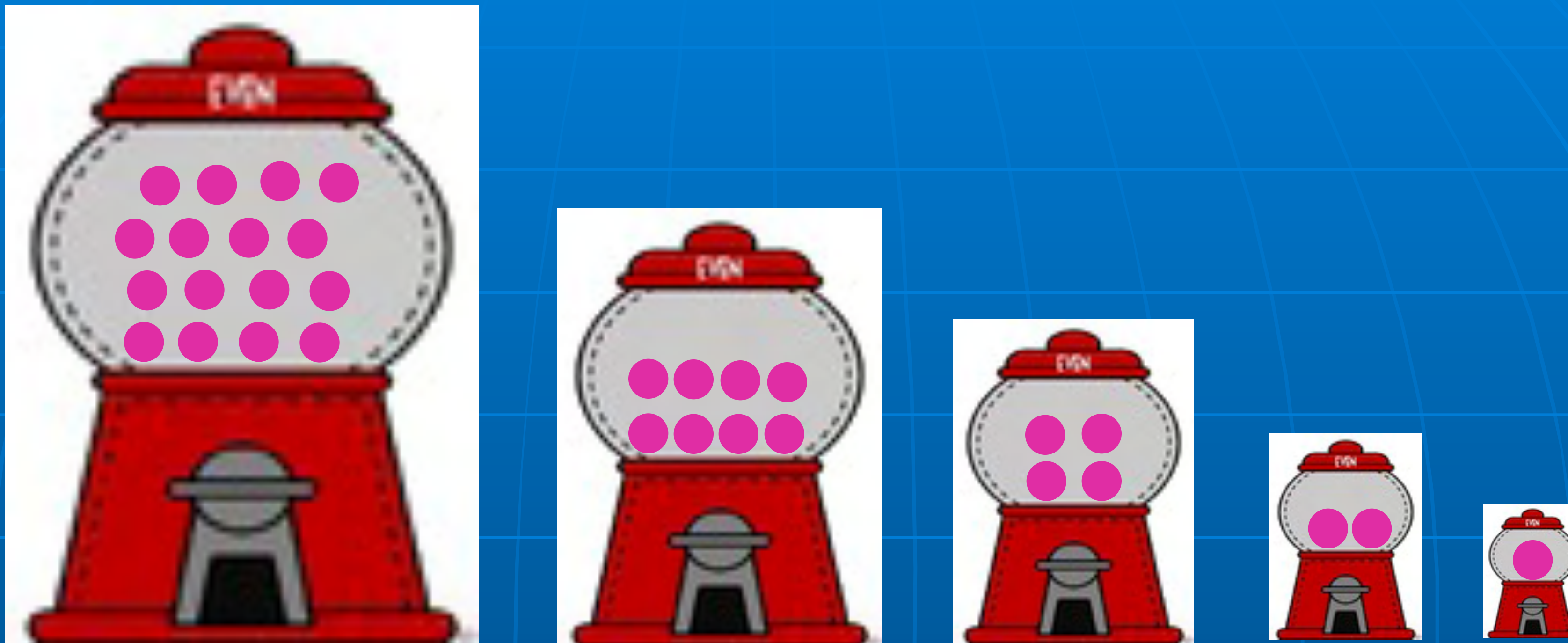




- The next one to the left is twice as big and can hold 2 gumballs (max)



- Once more to the left is a machine twice as big again. It can hold 4 gumballs.



- After that comes a machine capable of holding twice as many again, or 8 gumballs.

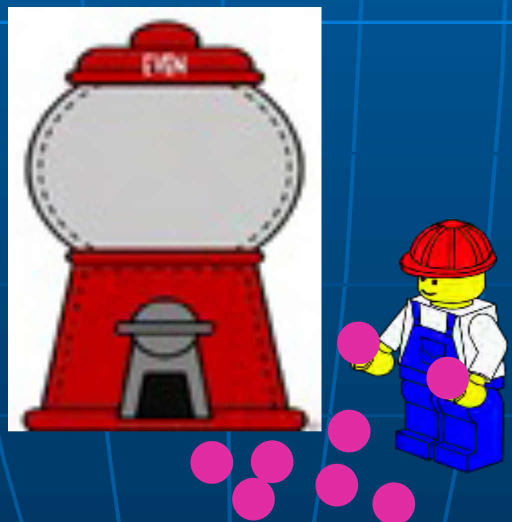
- Finally, the last machine in our line is a jumbo that can hold twice as many as the one before it, or 16 gumballs.

AND WHAT'S MORE

- **Each of these machines has a flap at the bottom, so that when you pull the lever, ALL the gumballs in that machine fall out.**
- **In other words, these machines are always either completely full, or completely empty.**
- **Now, you might be wondering "If gravity is emptying these machines – how are they filling back up exactly?"**

THE SMALL PERSON…

- **This is not a problem, because there is a small person behind the scenes happy to refill the machines for us - but only when told to do so!**

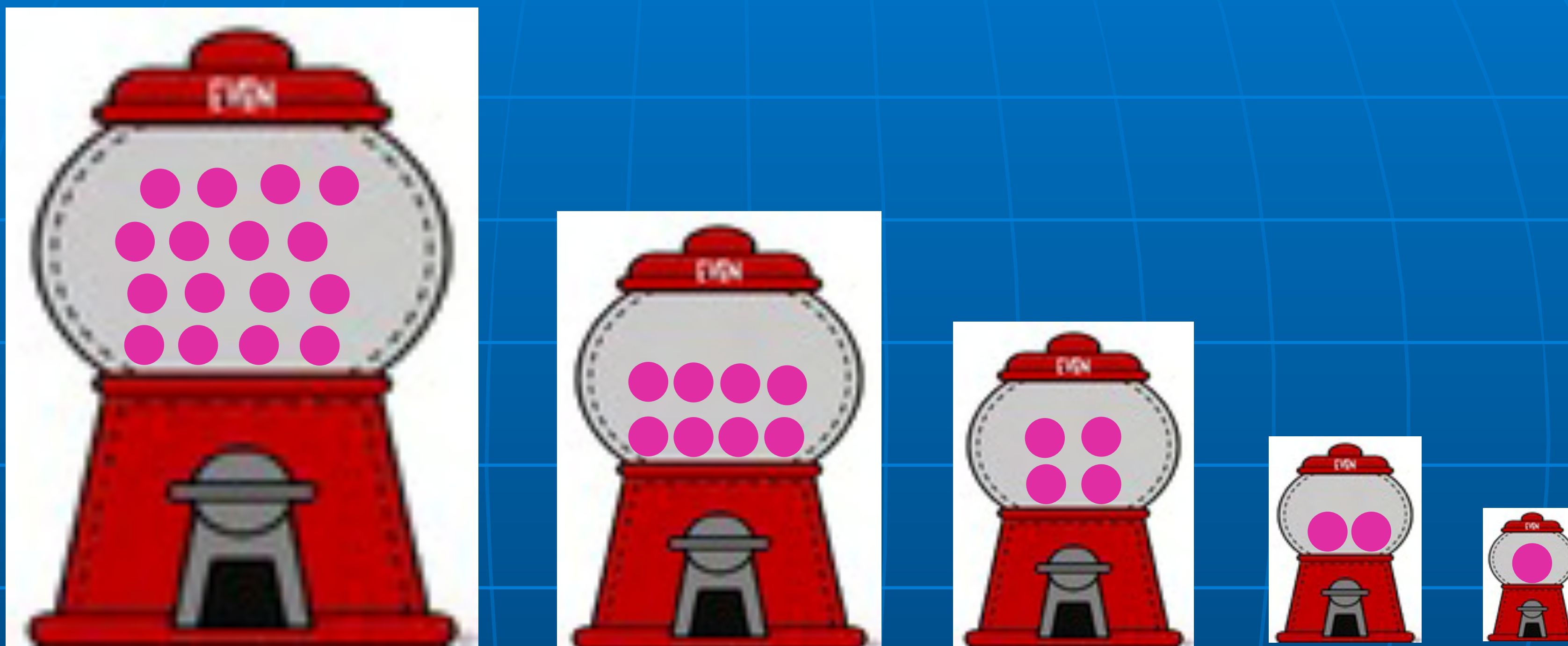


SO WHAT DO WE HAVE?

- **A row of five machines capable of holding gumballs as follows:**

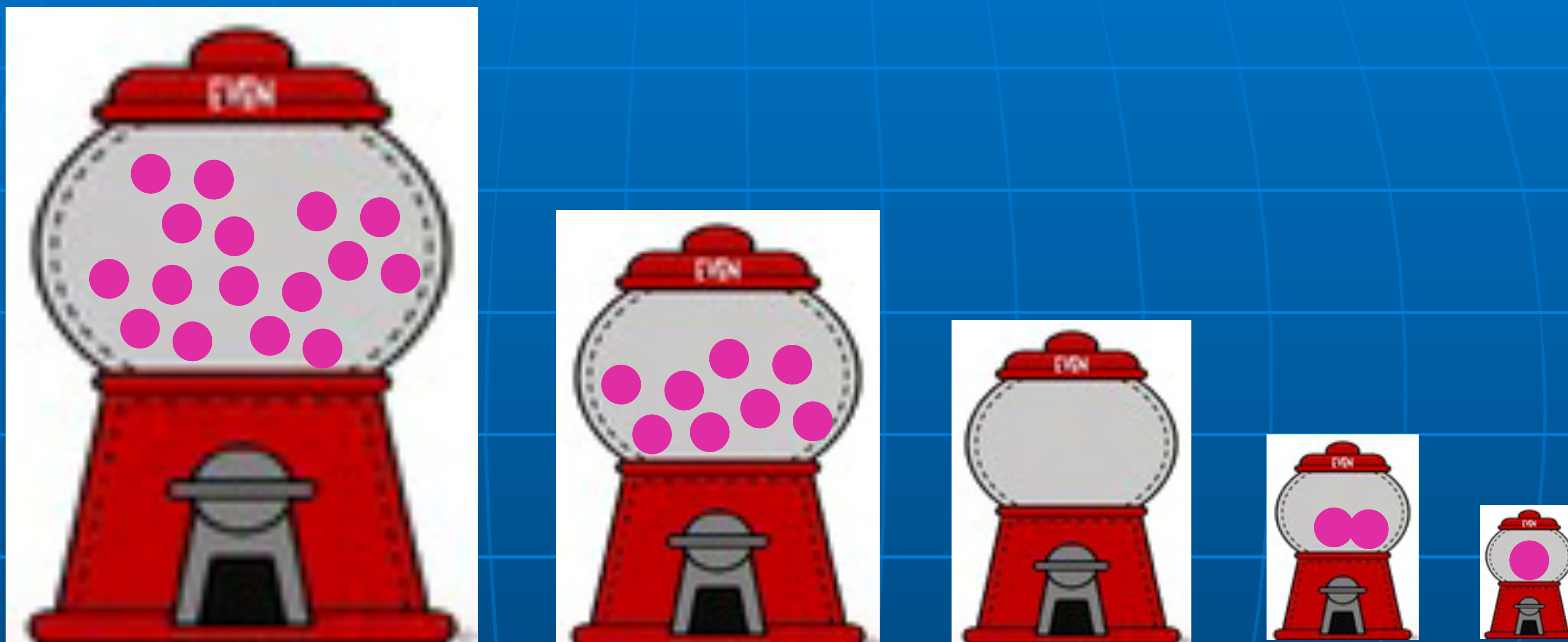
16 8 4 2 1

Now assuming all our machines are full, how many gumballs do we have?



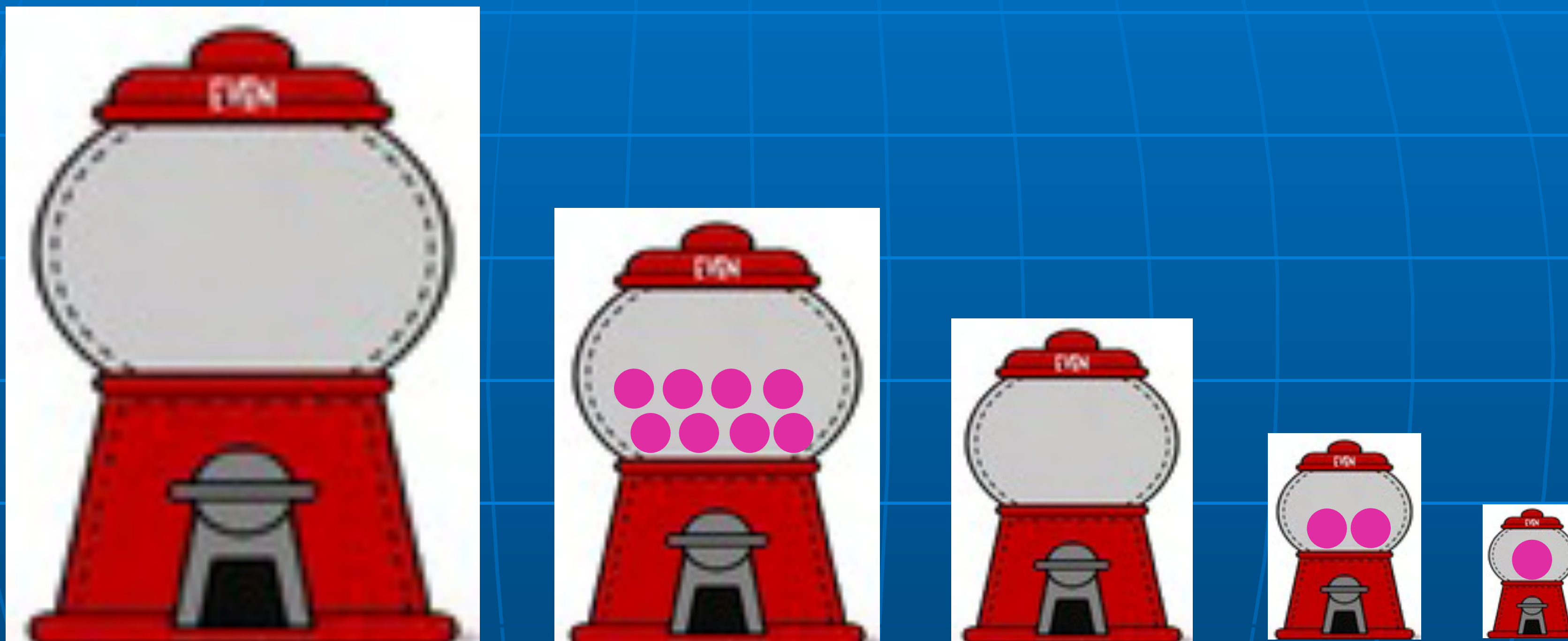
 **Easy: 16 + 8 + 4 + 2 + 1 = 31**

Assume the middle machine is empty; how many do we have?



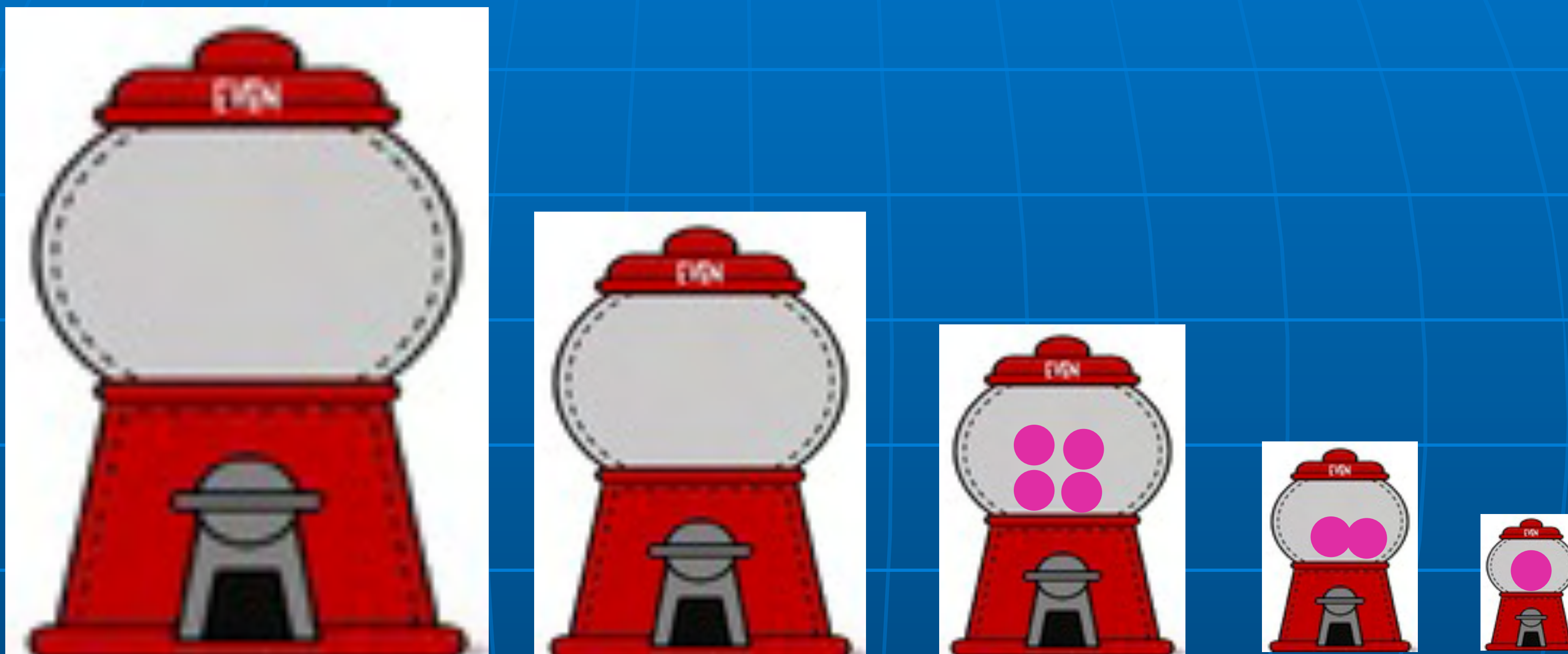
Easy: 16 + 8 + 0 + 2 + 1 = 27

Assume the left-hand machine and the middle one are empty; what do we have?



Easy: 0 + 8 + 0 + 2 + 1 = 11

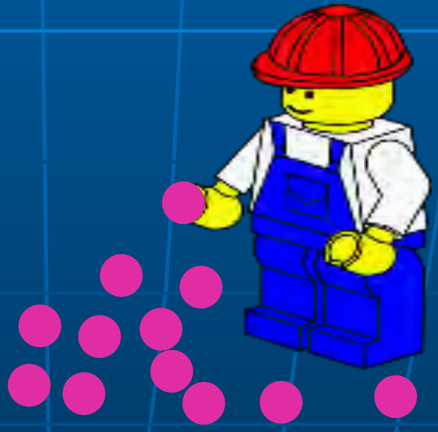
Assume only the first two machines are empty, we would have

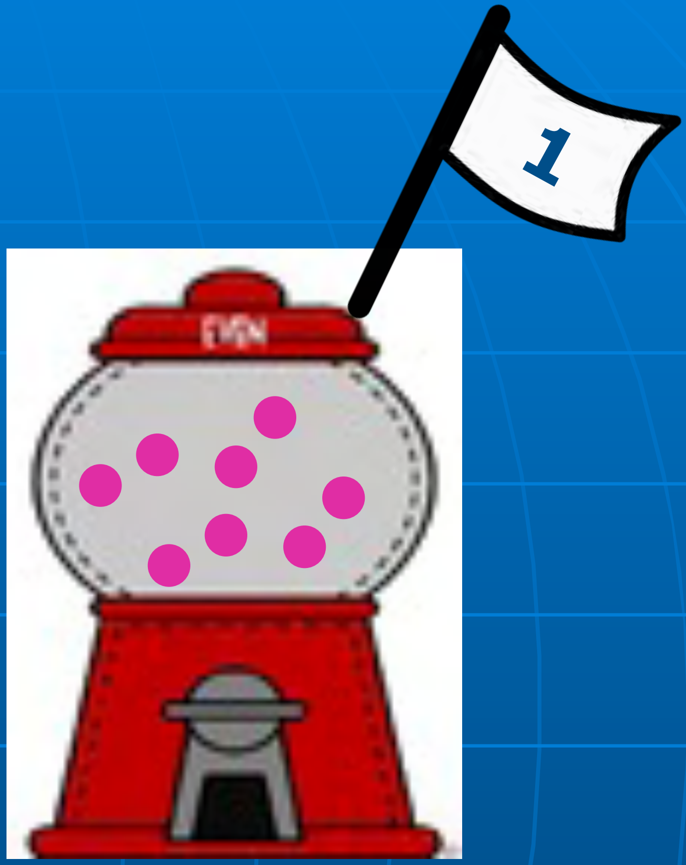


0 + 0 + 4 + 2 + 1 = 7

NOW THE CLEVER BIT

- It would help our small person if each of our gumball machines had two flags.

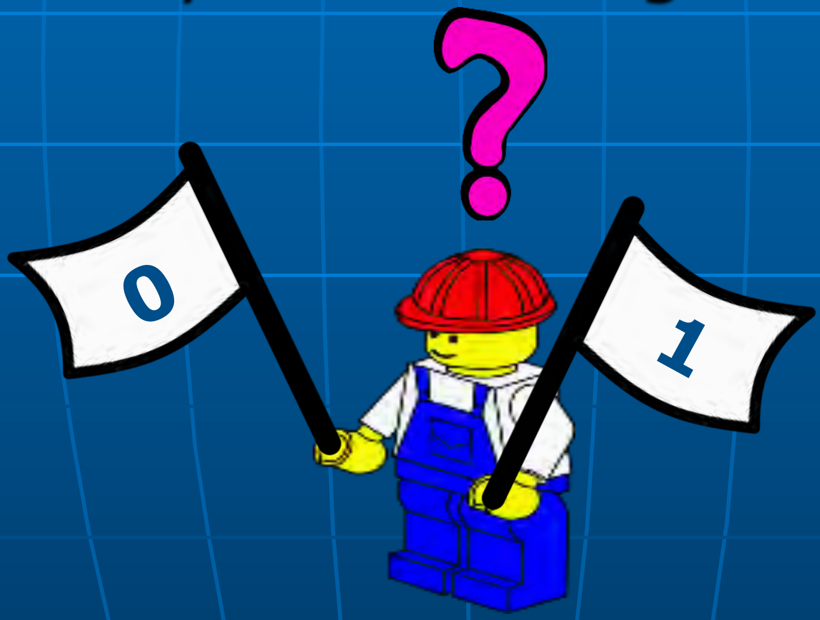




- One flag shows empty, and another shows full.
- Let’s paint a “0” on the flag showing “EMPTY” and a “1” on the flag showing "FULL.”

How might these flags help our small person?

- Turn and share your thoughts with a partner. Why use the flags? Do you agree?



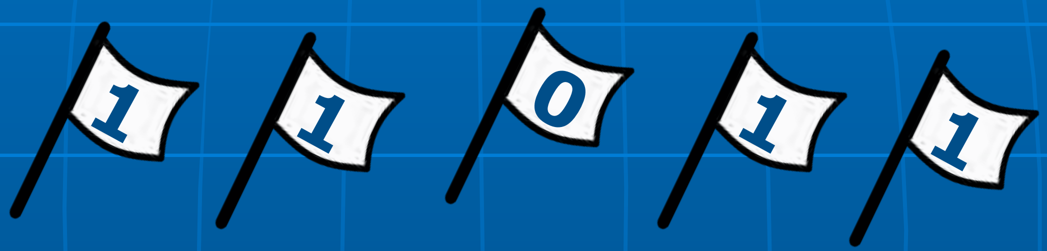
NOW WHAT DO WE HAVE?

- Think about our row of 5 gumball machines, each of which has a “0” flag or a “1” flag
- If all machines are full, we would see five flags showing a “1” like this:

(16) (8) (4) (2) (1)

Which means we have 31 gumballs

If the middle machine is empty, we would see:

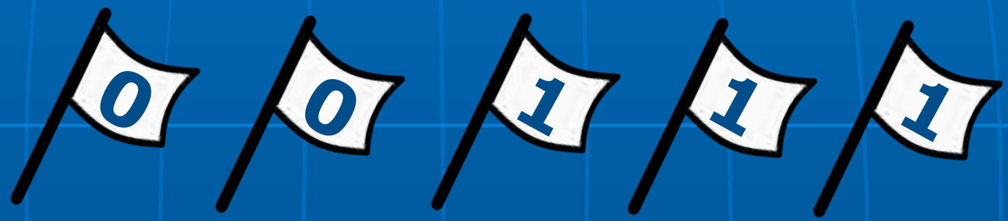


1 1 0 1 1

(16) (8) (0) (2) (1)

Which means we have 27 gumballs

And if the two machines on the left are empty we would see:



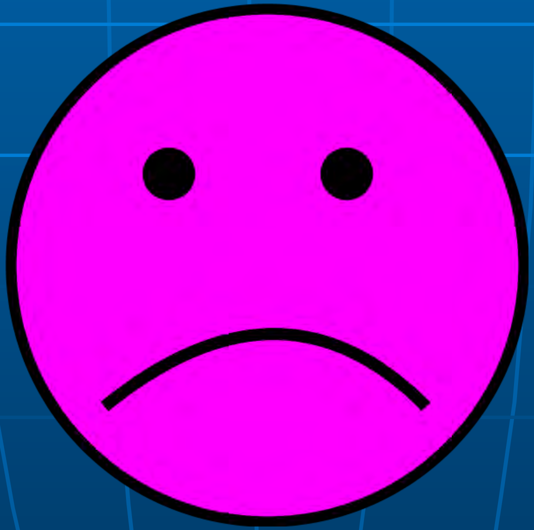
0 0 1 1 1

(0) (0) (4) (2) (1)

How many gumballs do we have now???
Explain how you know to a partner.

NOW… THE BAD NEWS

- The gumballs are not edible because they are only imaginary.



LET' S TAKE A BREAK

NOW … LET’S PLAY “BINARY CHAIRS”

- LISA. SEVERAL STEPS MISSING HERE. LET’S DISCUSS.

- TAKE 2 CHAIRS. ON THE BACK OF THE CHAIR ON THE RIGHT, TAPE A SHEET OF PAPER WITH A “1” ON IT.
- ON THE BACK OF THE OTHER CHAIR TAPE A SHEET WITH A “2” ON IT.
- HAVE A STUDENT STAND BEHIND EACH CHAIR WITH A SHEET OF PAPER WITH A “0” ON ONE SIDE AND A “1” ON THE OTHER. SEE PHOTO.
- HAVE ALL THE OTHER STUDENTS FIGURE OUT WHAT THE NUMBER OF GUMBALLS WOULD BE DEPENDING WHAT THE STUDENTS BEHIND THE CHAIRS HOLD UP.
- FOR EXAMPLE,
- IF THEY SEE:-   00, THAT WOULD BE ZERO.
- IF THEY SEE :- 01 THAT WOULD BE 0+1 = 1
- IF THEY SEE :- 10 THAT WOULD BE 2+0 = 2
- IF THEY SEE :- 11 THAT WOULD BE 2+1 = 3

- THEN ADD A THIRD CHAIR ON THE LEFT AND TAPE A SHEET OF PAPER WITH A “4” ON IT.
- STAND A STUDENT BEHIND THAT CHAIR, ALSO WITH A PAPER HAVING “0” ON ONE SIDE AND A “1” ON THE OTHER.
- THEN:-
- IF THEY SEE:- 1 0 0 THAT IS 4+0+0 = 4
- IF THEY SEE:- 1 1 1 THAT IS 4+2+1 = 7

- JUMPING AHEAD A LITTLE, SET UP FIVE CHAIRS, AND TAPE A PAPER ON EACH HAVING :- 16 8 4 2 1 RESPECTIVELY.
- FOR THIS, THERE ARE ENDLESS COMBINATIONS, SUCH AS:-

- CHAIR 16 8 4 2 1

  PAPERS 1 0 1 0 0 = 16+0+4+0+0 = 20

  PAPERS 0 1 0 1 1 = 0+8+0+2+1 = 11

  AND SO ON. KEEP GOING UNTIL YOU HAVE HAD ENOUGH.

QUESTION. HOW MANY COMBINATIONS CAN YOU GET WITH FIVE CHAIRS?

NOTE THAT THE STUDENTS IN THE DEMONSTRATION PHOTOS GOT UP TO SIX CHAIRS WHICH GAVE THEM 64 COMBINATIONS.

That was fun, but wait…

How does a computer use binary <u>numbers</u> to make the <u>letters</u> of our alphabet?

Turn and talk to a partner about your prediction.

Simple.

They use a system of 26 coded numbers.

(have a handout)

CODED LETTERS

A	=	01000001	J	=	01001010	S	=	01010011
B	=	01000010	K	=	01001011	T	=	01010100
C	=	01000011	L	=	01001100	U	=	01010101
D	=	01000100	M	=	01001101	V	=	01010110
E	=	01000101	N	=	01001110	W	=	01010111
F	=	01000110	O	=	01001111	X	=	01011000
G	=	01000111	P	=	01010000	Y	=	01011001
H	=	01001000	Q	=	01010001	Z	=	01011010
I	=	01001001	R	=	01010010			

Note 1: The leading "**010**" above indicates an upper case letter. It is shown in color here simply for ease of identification. Color does NOT appear in the computer itself.

Note 2: A leading "011" would indicate a lower case letter.

Note 3: For example, "C", which is No. 3 in the alphabet is also 3 in binary. "Z", which is No. 26 in the alphabet, is also 26 in binary terms, which figures.

This system is the basis of something called ASCII (commonly pronounced as "Askey"), which stands for "American Standard Code for Information Interchange" …a good buzz-word with which to impress your friends and family.

NOW TRANSLATE THE FOLLOWING MESSAGE, USING THE TABLE ON YOUR HANDOUT

- **01000001**

- **01001001**
- **01010011**

- **01000110**
- **01001111**
- **01010010**

- **01000001**
- **01010000**
- **01010000**
- **01001100**
- **01000101**

SO NOW YOU CAN SEND CODED MESSAGES TO YOUR FRIENDS

01001000, 01000001, 01010110, 01000101

01000001

01001110, 01001001, 0100011, 01000101

01000100, 01000001, 01011001 !

TRY IT!

TURN YOUR HANDOUT OVER AND WRITE A MESSAGE TO A FRIEND IN BINARY CODE (use a complete sentence with several words) ***Consider using a number as well (smaller than 100 please)
WHEN WE'RE FINISHED WE'LL TRADE AND DECODE!!!

Wait! That's a whopping big bunch of numbers!

How many numbers can a computer 'store' anyways?

Great question!

- Binary Digit = 1 "Bit"
- 8 Bits = 1 "Byte"
- 1000 Bytes = 1 "Kilobyte"
- 1000 Kilobytes = 1 "Megabyte"
- 1000 Megabytes = 1 "Gigabyte"
- 1000 Gigabytes = 1 "Terabyte" ← Typical home computer in 2015
- 1000 Terabytes = 1 Petabyte
- 1000 Petabytes = 1 Exabyte
- 1000 Exabytes = 1 Zettabyte
- 1000 Zettabytes = 1 Yottabyte
- 1000 Yottabytes = 1 Brontobyte
- 1000 Brontobytes = 1 Geopbyte

That's roughly 8 TRILLION of our binary "1's" and "0's" – Oh My!

WHY ARE BINARY NUMBERS SO USEFUL?

- Despite what you might think, computers are really not smart. All they do is count zeros and ones, time after time after time.
- And of course, computers never get tired, never take coffee breaks, and (usually) never make mistakes.
- The smart part comes with the people who write the “Computer Code” which organizes the zeros and ones into something meaningful.

- YOU COULD BE ONE OF THEM!

This little document is intended as a preliminary "try-out". It has been tested on several fourth-graders, in Alberta and Ontario, who said they thought it "fun" and "easy to understand".

If you have any comments or suggestions, please do not hesitate to contact:- **dehepburn@sympatico.ca** **or** **anis@ucalgary.ca**

- The next slide is printed in black & white, with the intention that copies may easily be run off on the school photocopy machine and given to the students to take home after the lesson.

Name: ______________________ Date: __________________

BINARY CODED LETTERS

A	=	01000001	J	=	01001010	S	=	01010011
B	=	01000010	K	=	01001011	T	=	01010100
C	=	01000011	L	=	01001100	U	=	01010101
D	=	01000100	M	=	01001101	V	=	01010110
E	=	01000101	N	=	01001110	W	=	01010111
F	=	01000110	O	=	01001111	X	=	01011000
G	=	01000111	P	=	01010000	Y	=	01011001
H	=	01001000	Q	=	01010001	Z	=	01011010
I	=	01001001	R	=	01010010			

HAVE A NICE DAY