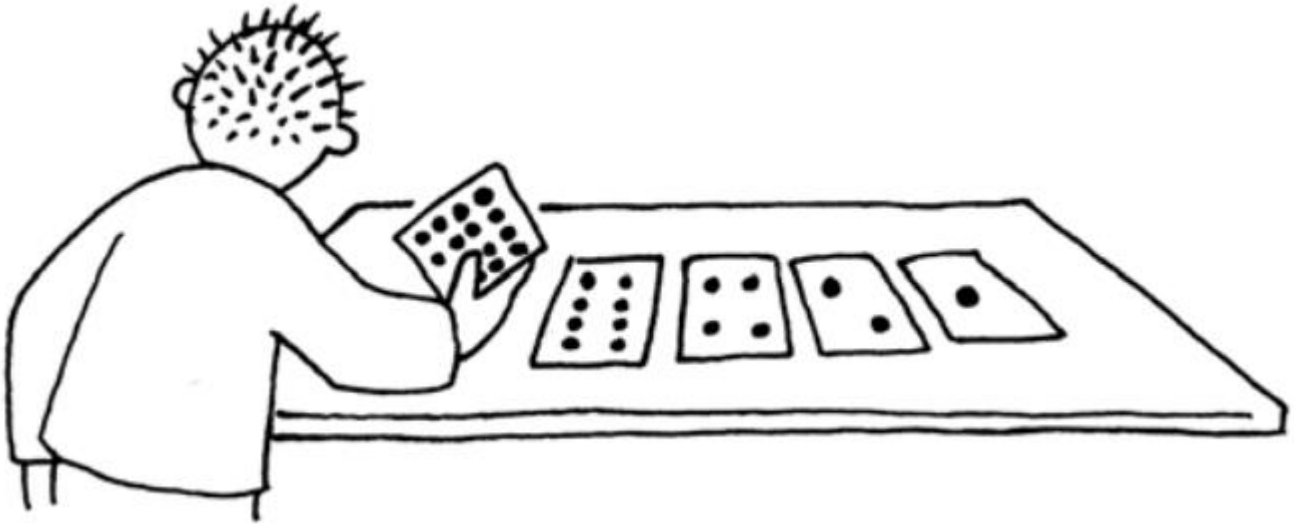
# Binary

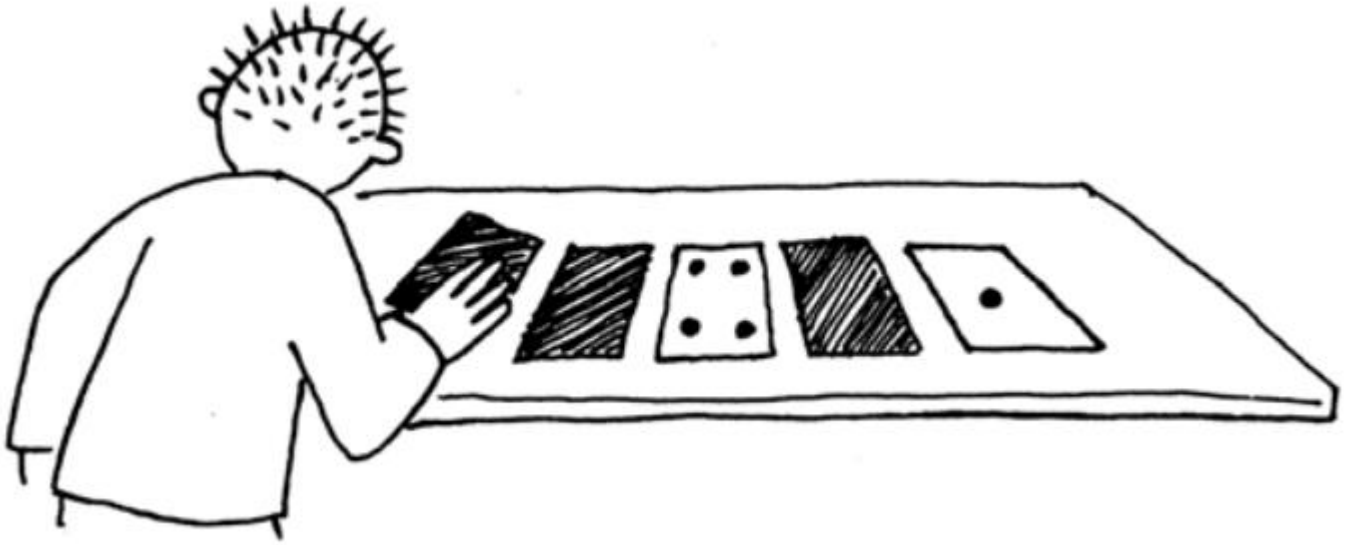
Grade 11 Computer Science

# Binary

- The number system used by computers.
- Everything on a computer is translated to binary, is stored in binary, and is transmitted over the internet in binary.
- It is used instead of regular Base-10 numbers because it is easy to store on hardware. Numbers can be reduced to a series of on/off commands.

# Cards Set Up:

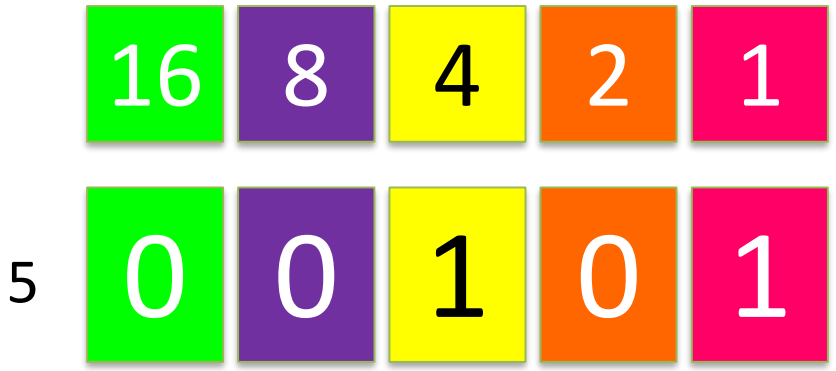




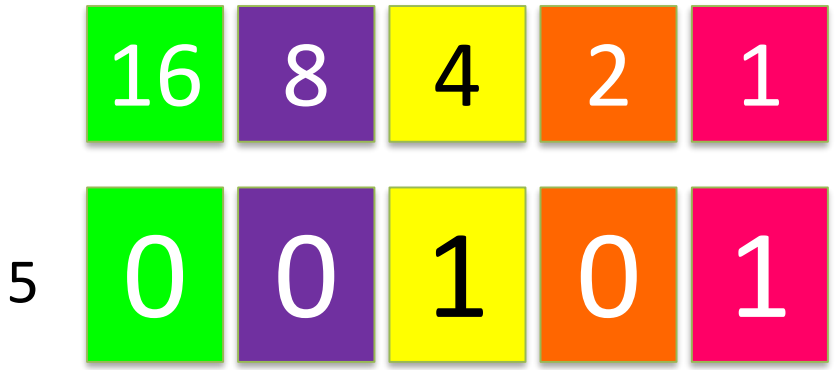
1. Which cards are needed to make 5:

1. Which cards are needed to make 5:

Can you make 5 any other way?



Can you make 5 any other way?




No. As with decimal numbers, there is only one way to make each number.

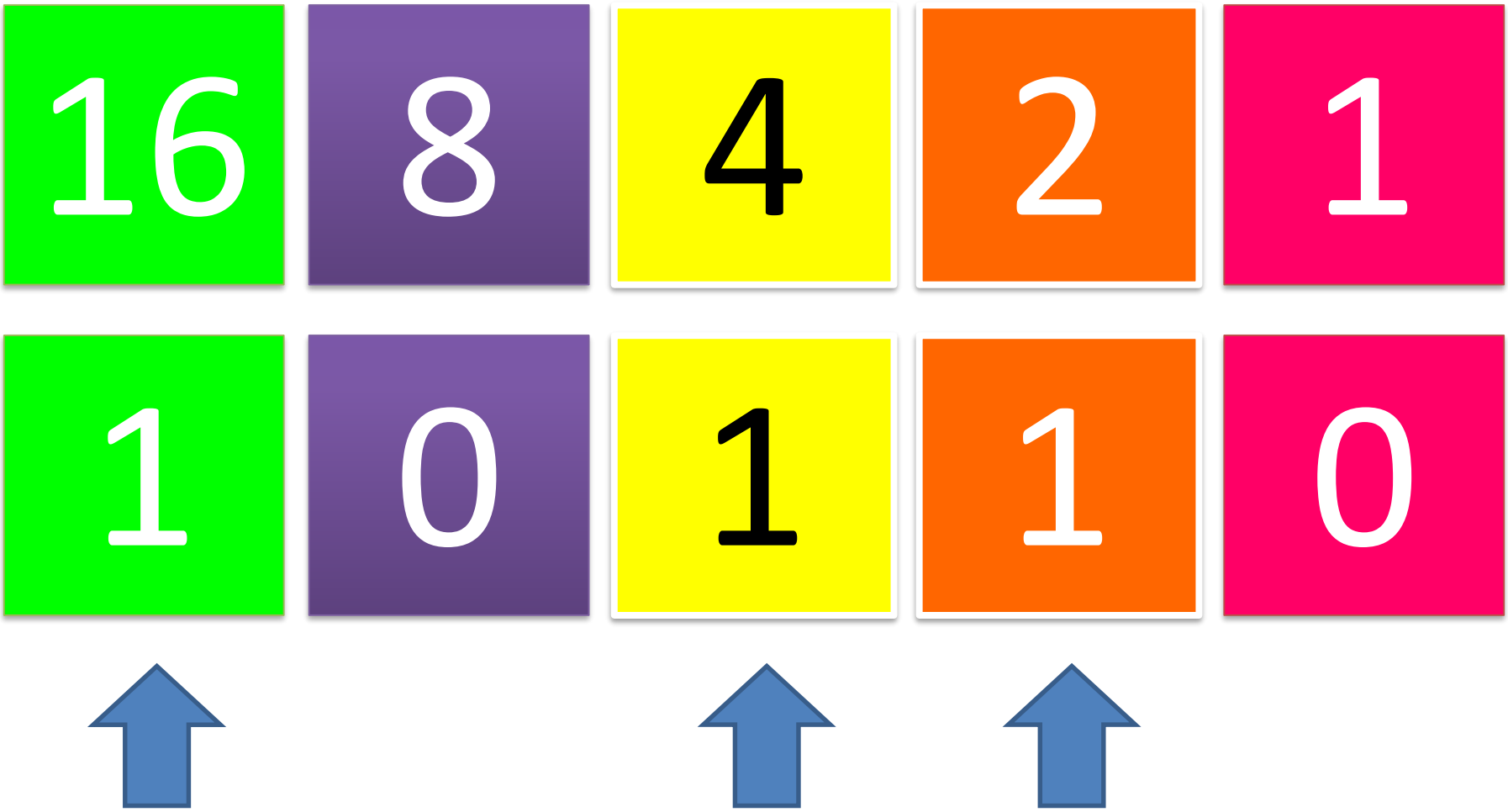
2. Which cards are needed to make 13:

2. Which cards are needed to make 13:


8 + 4 + 1 = 13

3. Which cards are needed to make 22:

3. Which cards are needed to make 22:




16 + 4 + 2 = 22

4. What is the biggest number that you can make with these cards?

4. What is the biggest number that you can make with these cards?


16 + 8+ 4 + 2 + 1 = 31

5. What is the smallest number that you can make with these cards?

5. What is the smallest number that you can make with these cards?


That's it. It is zero.

# 6. Where do the columns come from?

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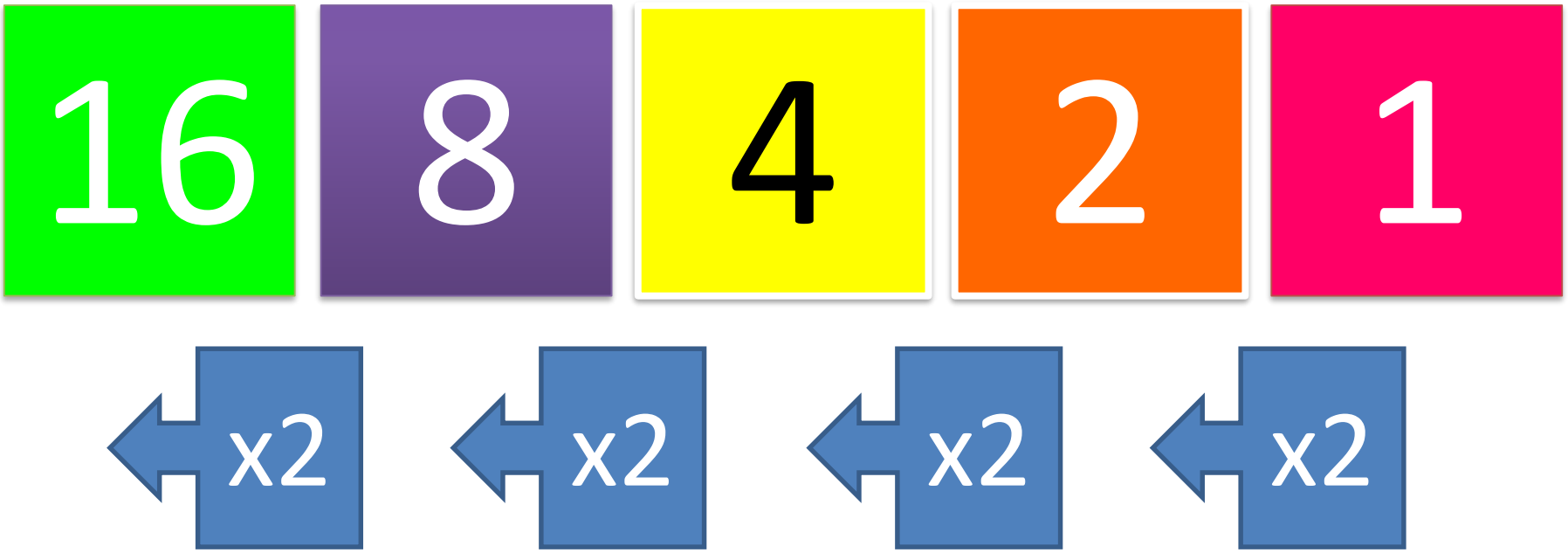
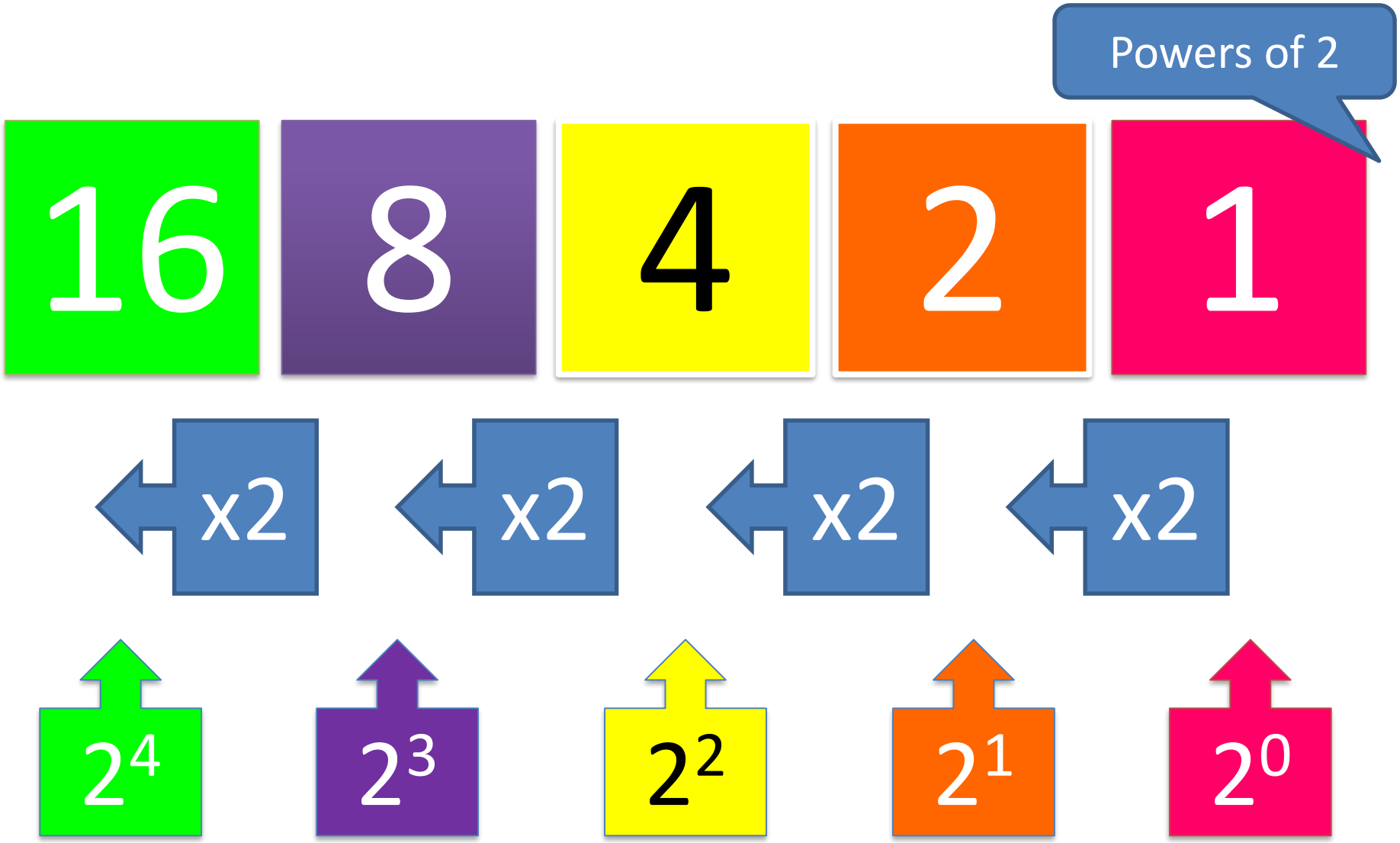
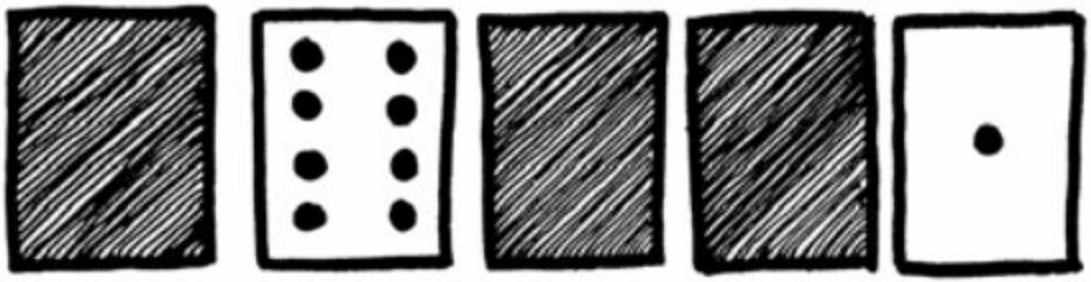


# 6. Where do the columns come from?





0 1 0 0 1 = 9

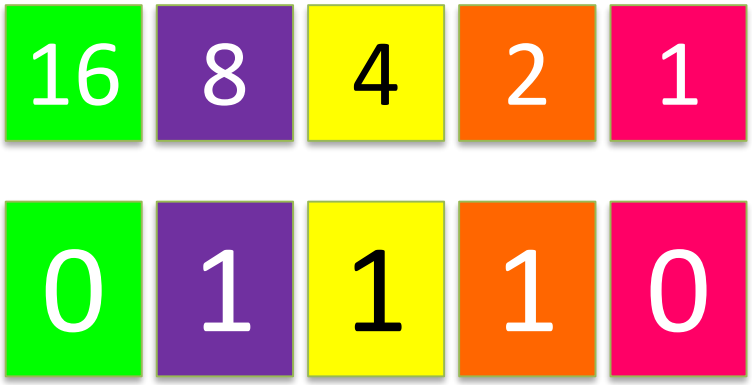
# 7. Count from 1 to 10.

# 7. Count from 1 to 10.

| | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 1 |
| 2 | 0 | 0 | 0 | 1 | 0 |
| 3 | 0 | 0 | 0 | 1 | 1 |
| 4 | 0 | 0 | 1 | 0 | 0 |
| 5 | 0 | 0 | 1 | 0 | 1 |

| | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|
| 6 | 0 | 0 | 1 | 1 | 0 |
| 7 | 0 | 0 | 1 | 1 | 1 |
| 8 | 0 | 1 | 0 | 0 | 0 |
| 9 | 0 | 1 | 0 | 0 | 1 |
| 10 | 0 | 1 | 0 | 1 | 0 |

# Writing in “pure” binary.




01110

And drop the LEADING zeros....

1110

# How to Write in Binary

- Columns are powers of 2:
  32, 16, 8, 4, 2, 1
- Start columns on the RIGHT using 1. Use as many as you need.
- If you need the column, write a 1, otherwise, write a 0.
- With NUMBERS, you don't need leading zeros, but you do need trailing zeros. 00100 can be written as 100 if it is storing a number (not true for letters)

Please note that I changed the numbers! Don't copy!

0. Circle the numbers that sum to the total given.

(a) Total: 6

16 8 4 2 1

(b) Total: 10

16 8 4 2 1

(c) Total: 23

16 8 4 2 1

(d) Total: 31

16 8 4 2 1

1. Translate from decimal to binary.

(a) $5_{dec}$

16 8 4 2 1

(b) $4_{dec}$

16 8 4 2 1

(c) $20_{dec}$

16 8 4 2 1

(d) $29_{dec}$

16 8 4 2 1

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(a) Total: 6

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(b) Total: 10

16 8 4 2 1

(c) Total: 23

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(a) $5_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 |

(b) $4_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| | | | | |

(c) $20_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| | | | | |

(d) $29_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| | | | | |

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| 0 | 0 | 1 | 0 | 0 |

(c) $20_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| | | | | |

(d) $29_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| | | | | |

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0. Circle the numbers that sum to the total given.

(a) Total: 6

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|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 |

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| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 |

(c) $20_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 |

(d) $29_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| | | | | |

Please note that I changed the numbers! Don't copy!

0. Circle the numbers that sum to the total given.

(a) Total: 6

16 8 (4) (2) 1

(b) Total: 10

16 (8) 4 (2) 1

(c) Total: 23

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

(d) Total: 31

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

1. Translate from decimal to binary.

(a) $5_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 1 |

(b) $4_{dec}$

| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 |

(c) $20_{dec}$

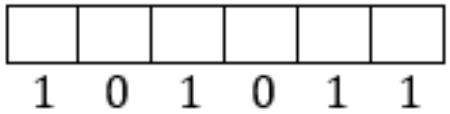
| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 |

(d) $29_{dec}$

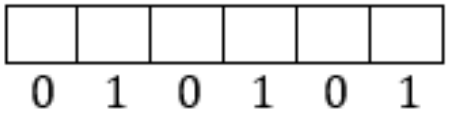
| 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|
| 1 | 1 | 1 | 0 | 1 |

Please note that I changed the numbers! Don't copy!

3. Translate from binary to decimal. (write in the columns first).

(a) 


Answer: _____

(b) 


Answer: _____

Please note that
I changed the
numbers!
Don't copy!

3. Translate from binary to decimal. (write in the columns first).

(a)

| 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 1 | 1 |

Answer: _____

(b)

| 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 1 |

Answer: _____

Please note that I changed the numbers! Don't copy!

3. Translate from binary to decimal. (write in the columns first).

(a) 32 + 8 + 2 + 1

| 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 1 | 1 |

Answer: _____

(b) 16 + 4 + 1

| 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 1 |

Answer: _____

Please note that I changed the numbers! Don't copy!

3. Translate from binary to decimal. (write in the columns first).

(a) 32 + 8 + 2 + 1

| 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 1 | 1 |

Answer: 43

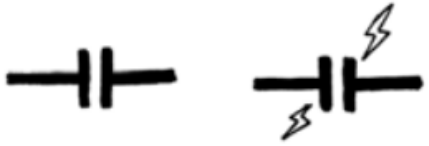
(b) 16 + 4 + 1

| 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|
| 0 | 1 | 0 | 1 | 0 | 1 |

Answer: 21

Computers today use the binary system to represent information. It is called binary because only two different digits are used. It is also known as base two (humans normally use base 10). Each zero or one is called a *bit* (**b**inary dig**it**). A bit is usually represented in a computer's main memory by a transistor that is switched on or off, or a capacitor that is charged or discharged.

0 1

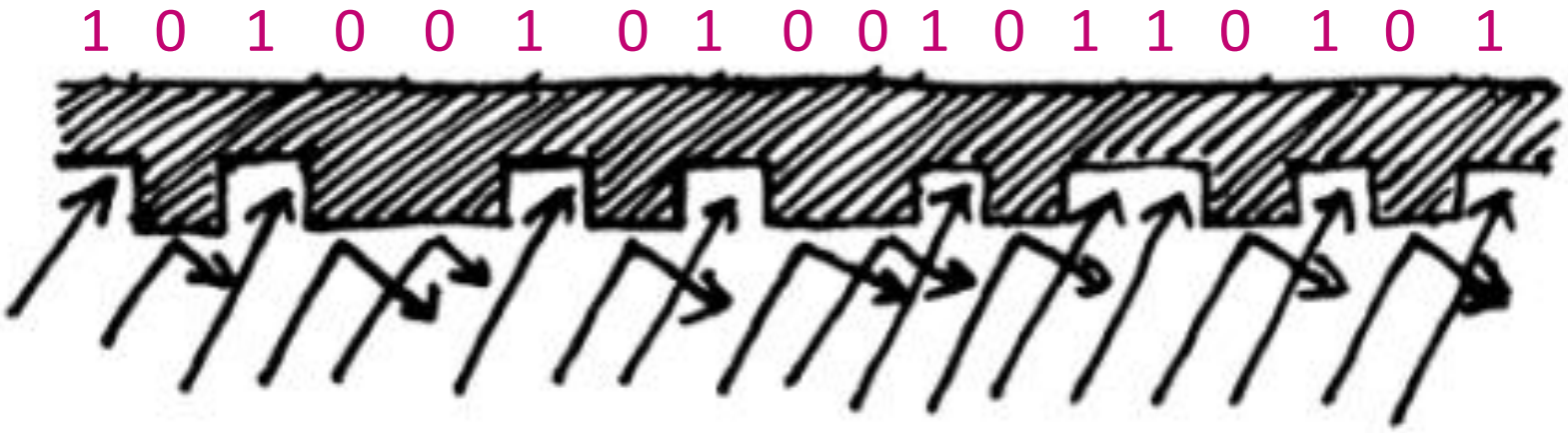


0 1

When data must be transmitted over a telephone line or radio link, high and low-pitched tones are used for the ones and zeros. On magnetic disks (floppy disks and hard disks) and tapes, bits are represented by the direction of a magnetic field on a coated surface, either North-South or South-North.


1 1 0 1 0 0 1

Audio CDs, CD-ROMs and DVDs store bits optically—the part of the surface corresponding to a bit either does or does not reflect light.



# Translate these symbols to Base-10 (decimal) numbers.

16 8 4 2 1

(☑=1, ☒=0)

= 9

4 2 1

(⇧=1, ⇩=0)

= 5

(⊙=1, ○=0)

=

(=1, =0)

=

(☺=1, ☹=0)

=

(=1, =0)

=

(+=1, ×=0)

=

(↻=1, ↺=0)

=

(▲=1, ▼=0)

=

(♠=1, ♣=0)

=

Please note that I changed the numbers! Don't copy!

5. A bit is a **Bi**nary Digi**t**.

(a) The number 22 is 10110. How many bits are needed to store it? _____

(b) The number 15 is 1111. How many bits are needed to store it? _____

(c) The picture is encoded: 10101010101011. How many bits are needed to store it? _____

Eight bits is a byte.

(f) You have 2 byte. How many bits do you have? _____

(g) You have 9 bytes. How many bits do you have? _____

(i) You have 24 bits. How many bytes do you have? _____

12345

10110

Please note that I changed the numbers! Don't copy!

5. A bit is a **Bi**nary Digi**t**.

(a) The number 22 is 10110. How many bits are needed to store it? 5

(b) The number 15 is 1111. How many bits are needed to store it? _____

(c) The picture is encoded: 10101010101011. How many bits are needed to store it? _____

Eight bits is a byte.

(f) You have 2 byte. How many bits do you have? _____

(g) You have 9 bytes. How many bits do you have? _____

(i) You have 24 bits. How many bytes do you have? _____

12345 1234

10110 1111

Please note that I changed the numbers! Don't copy!

5. A bit is a **Bi**nary Digi**t**.

(a) The number 22 is 10110. How many bits are needed to store it? 5

(b) The number 15 is 1111. How many bits are needed to store it? 4

(c) The picture is encoded: 10101010101011. How many bits are needed to store it? _____

Eight bits is a byte.

(f) You have 2 byte. How many bits do you have? _____

(g) You have 9 bytes. How many bits do you have? _____

(i) You have 24 bits. How many bytes do you have? _____

12345 1234

10110 1111

101010101011

Please note that I changed the numbers! Don't copy!

5. A bit is a **Bi**nary Digi**t**.

(a) The number 22 is 10110. How many bits are needed to store it? 5

(b) The number 15 is 1111. How many bits are needed to store it? 4

(c) The picture is encoded: 10101010101011. How many bits are needed to store it? 14

Eight bits is a byte.

(f) You have 2 byte. How many bits do you have? _____

(g) You have 9 bytes. How many bits do you have? _____

(i) You have 24 bits. How many bytes do you have? _____

12345 1234

10110 1111

101010101011

Please note that I changed the numbers! Don't copy!

5. A bit is a **Bi**nary Digi**t**.

(a) The number 22 is 10110. How many bits are needed to store it? 5

(b) The number 15 is 1111. How many bits are needed to store it? 4

(c) The picture is encoded: 10101010101011. How many bits are needed to store it? 14

Eight bits is a byte.

(f) You have 2 byte. How many bits do you have? 2 x 8

(g) You have 9 bytes. How many bits do you have? _____

(i) You have 24 bits. How many bytes do you have? _____

12345 1234

10110 1111

101010101011

Please note that I changed the numbers! Don't copy!

5. A bit is a **Bi**nary Digi**t**.

(a) The number 22 is 10110. How many bits are needed to store it? 5

(b) The number 15 is 1111. How many bits are needed to store it? 4

(c) The picture is encoded: 10101010101011. How many bits are needed to store it? 14

Eight bits is a byte.

(f) You have 2 byte. How many bits do you have? 2 x 8 16

(g) You have 9 bytes. How many bits do you have? _____

(i) You have 24 bits. How many bytes do you have? _____

12345 1234

10110 1111

101010101011

Please note that I changed the numbers! Don't copy!

5. A bit is a **Bi**nary Digi**t**.

(a) The number 22 is 10110. How many bits are needed to store it? 5

(b) The number 15 is 1111. How many bits are needed to store it? 4

(c) The picture is encoded: 10101010101011. How many bits are needed to store it? 14

Eight bits is a byte.

(f) You have 2 byte. How many bits do you have? 2 x 8 16

(g) You have 9 bytes. How many bits do you have? 9 x 8 72

(i) You have 24 bits. How many bytes do you have? _____

12345 1234

10110 1111

101010101011

Please note that I changed the numbers! Don't copy!

5. A bit is a **Bi**nary Digi**t**.

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Eight bits is a byte.

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(g) You have 9 bytes. How many bits do you have? 9 x 8 72

(i) You have 24 bits. How many bytes do you have? 24 / 8 3


6. Fill in this table:

| Column | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|
| Power of 2 | | | | | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| Number of bits needed | | | | | 5 | 4 | 3 | 2 | 1 |
| Largest number you can store | | | | | 31 | 15 | 7 | 3 | 1 |

7. If you translated it to binary, what is the largest decimal number you could store in....

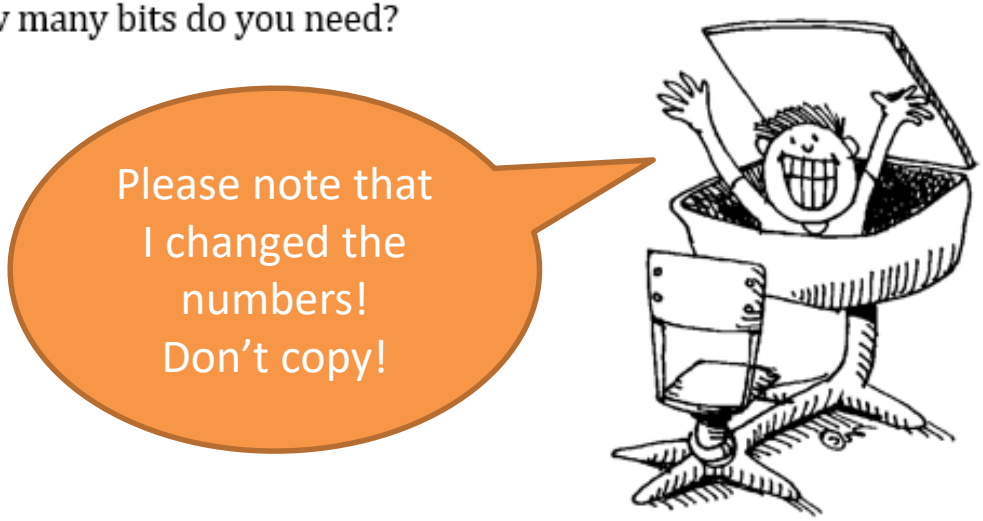
(a) 3 bits? _____ (b) 5 bits? _____ (c) 7 bits? _____

8. If you want to store these numbers, how many bits do you need?

(a) 45 _____

(b) 63 _____

(c) 98 _____




6. Fill in this table:

| Column | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|
| Power of 2 | $2^8$ | $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| Number of bits needed | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Largest number you can store | 511 | 255 | 127 | 63 | 31 | 15 | 7 | 3 | 1 |

7. If you translated it to binary, what is the largest decimal number you could store in....

(a) 3 bits? 7 (b) 5 bits? _____ (c) 7 bits? _____

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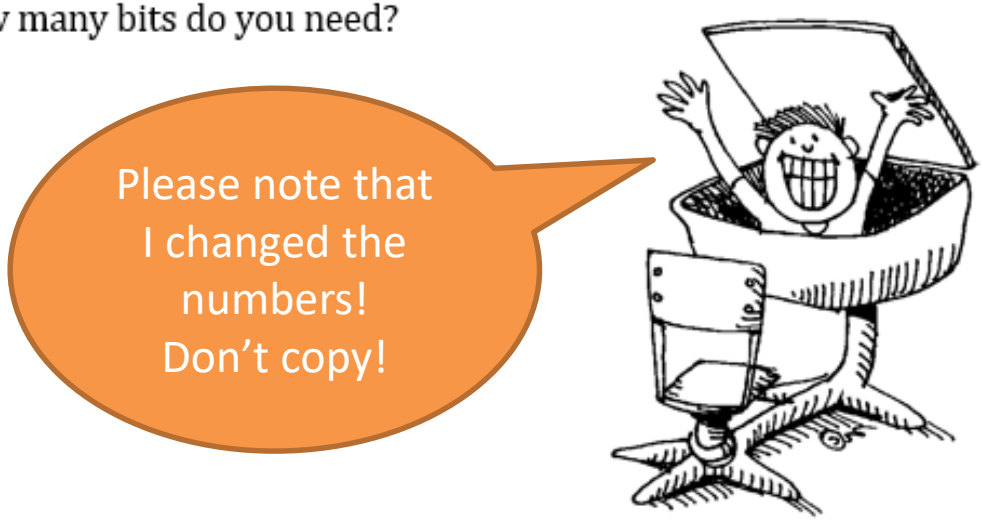


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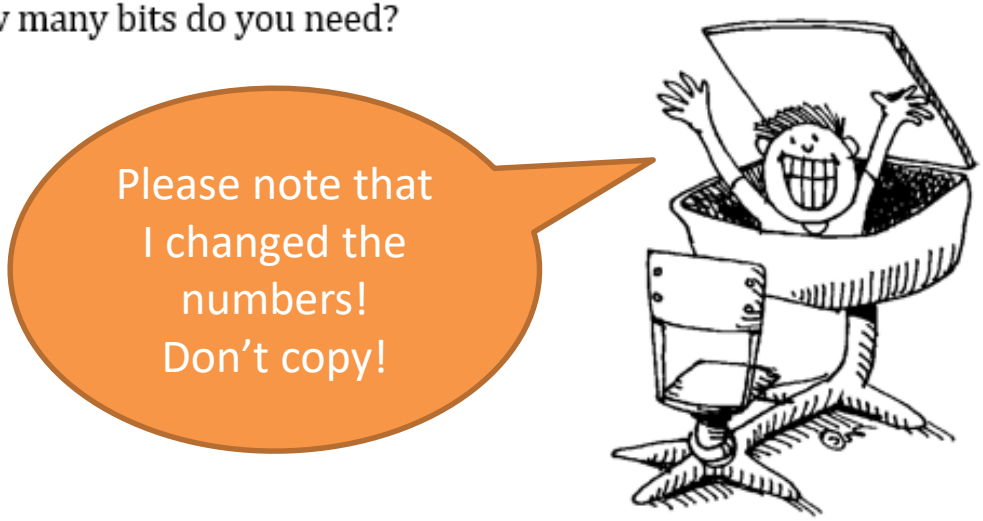


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| Number of bits needed | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Largest number you can store | 511 | 255 | 127 | 63 | 31 | 15 | 7 | 3 | 1 |

7. If you translated it to binary, what is the largest decimal number you could store in....

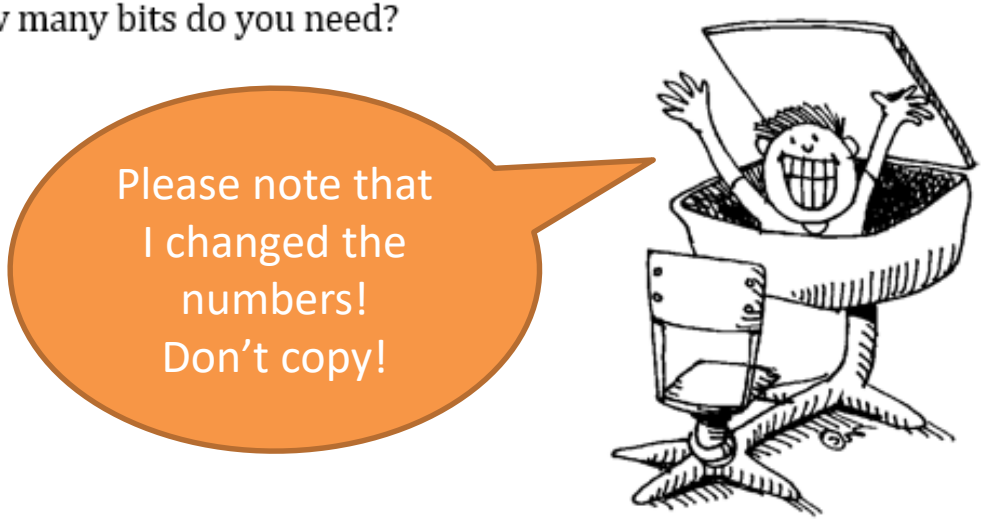
(a) 3 bits? 7 (b) 5 bits? 31 (c) 7 bits? 127

8. If you want to store these numbers, how many bits do you need?

(a) 45 _____

(b) 63 _____

(c) 98 _____




6. Fill in this table:

| Column | 256 | 128 | 64 | 32 | 16 | 8 | 4 | 2 | 1 |
|---|---|---|---|---|---|---|---|---|---|
| Power of 2 | $2^8$ | $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
| Number of bits needed | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 |
| Largest number you can store | 511 | 255 | 127 | 63 | 31 | 15 | 7 | 3 | 1 |

7. If you translated it to binary, what is the largest decimal number you could store in....

(a) 3 bits? 7 (b) 5 bits? 31 (c) 7 bits? 127

8. If you want to store these numbers, how many bits do you need?

(a) 45 6

(b) 63 _____

(c) 98 _____

Please note that I changed the numbers! Don't copy!

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|---|---|---|---|---|---|---|---|---|---|
| Power of 2 | $2^8$ | $2^7$ | $2^6$ | $2^5$ | $2^4$ | $2^3$ | $2^2$ | $2^1$ | $2^0$ |
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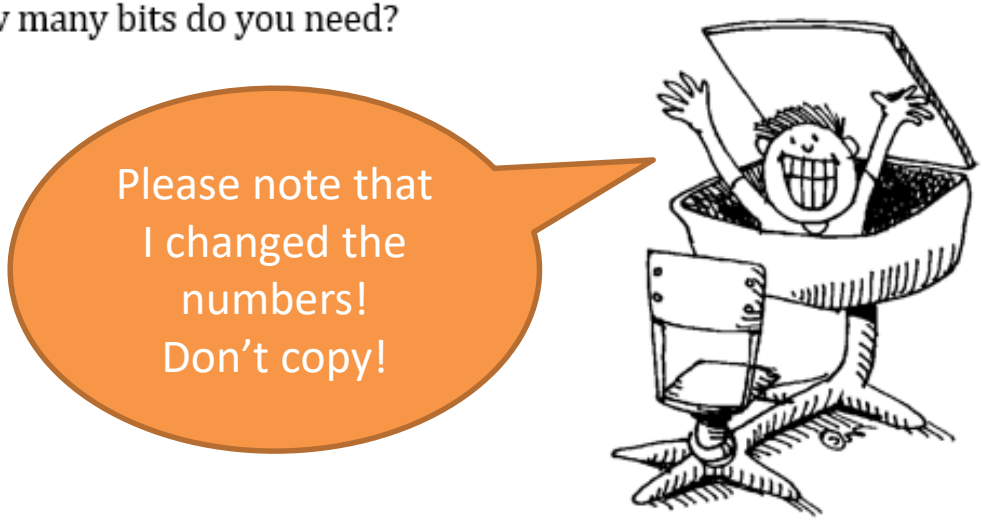


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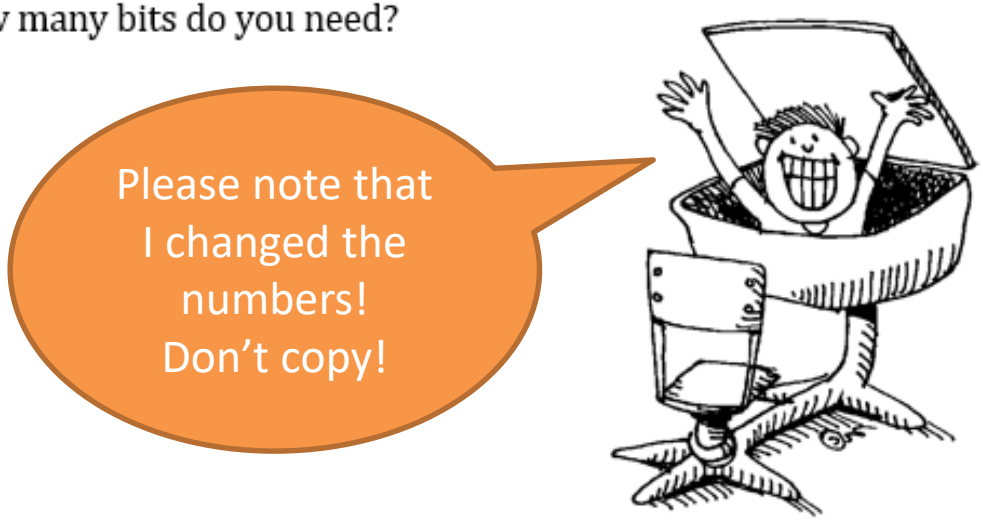
(c) 98 7

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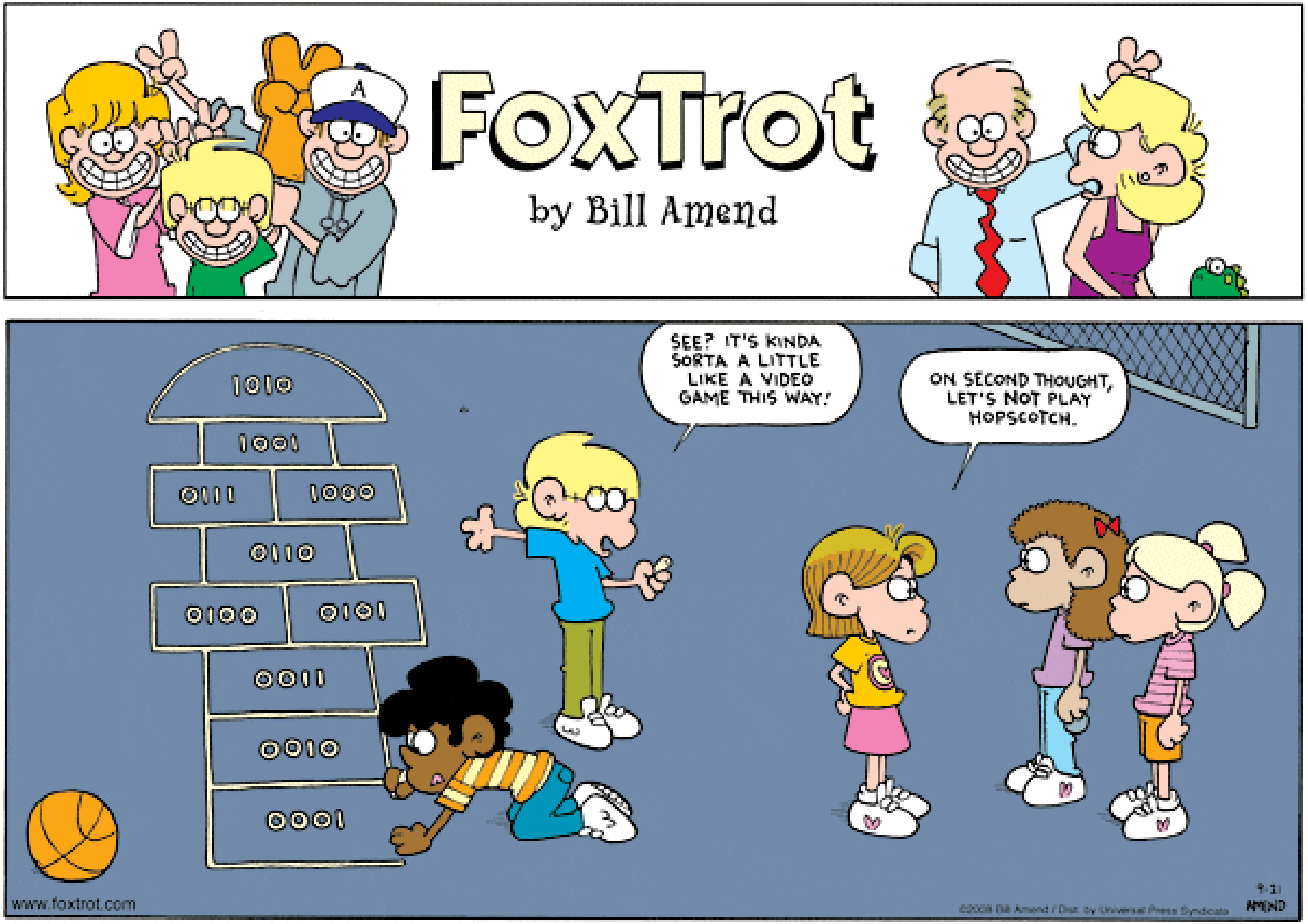
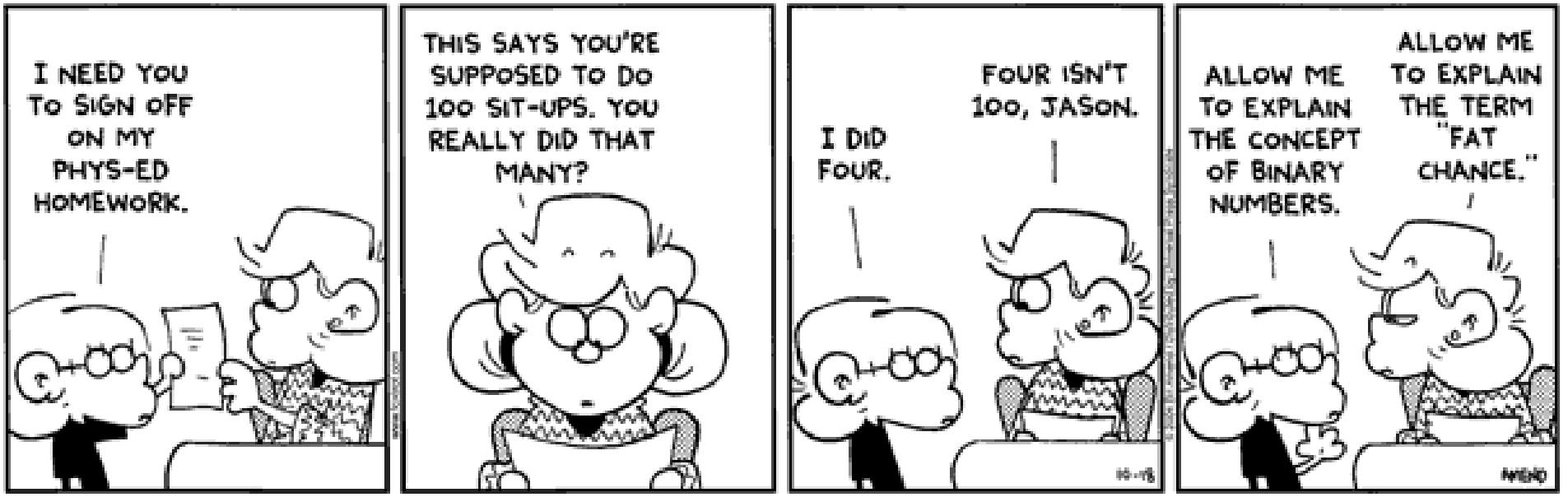
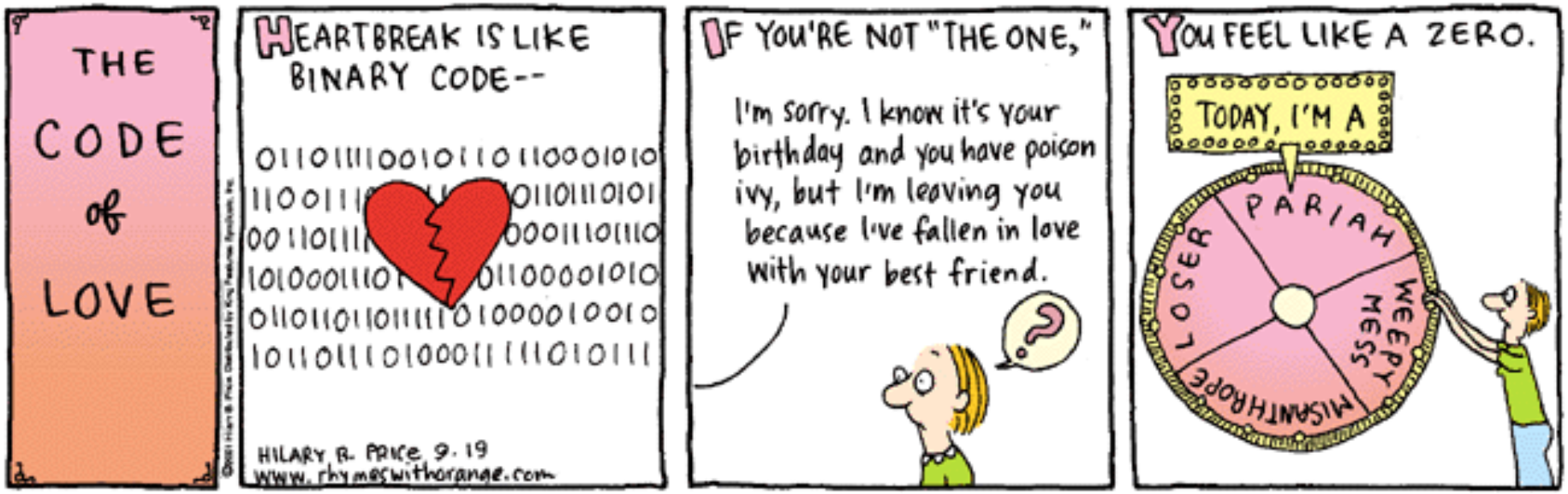

FoxTrot
by Bill Amend
1010
1001
0111
1000
0110
0100
0101
0011
0010
0001
SEE? IT'S KINDA SORTA A LITTLE LIKE A VIDEO GAME THIS WAY!
ON SECOND THOUGHT, LET'S NOT PLAY HOPSCOTCH.
www.foxtrot.com
©2008 Bill Amend / Dist. by Universal Press Syndicate
9-21
AMEND


I NEED YOU TO SIGN OFF ON MY PHYS-ED HOMEWORK.
THIS SAYS YOU'RE SUPPOSED TO DO 100 SIT-UPS. YOU REALLY DID THAT MANY?
I DID FOUR.
FOUR ISN'T 100, JASON.
ALLOW ME TO EXPLAIN THE CONCEPT OF BINARY NUMBERS.
ALLOW ME TO EXPLAIN THE TERM "FAT CHANCE."
THE END


THE CODE of LOVE
HEARTBREAK IS LIKE BINARY CODE--
HILARY B. PRICE, 9.19
WWW.rhymeswithorange.com
IF YOU'RE NOT "THE ONE,"
I'm sorry. I know it's your birthday and you have poison ivy, but I'm leaving you because I've fallen in love with your best friend.
YOU FEEL LIKE A ZERO.
TODAY, I'M A
PARIAH
WEEPY MESS
MISANTHROPE
LOSER