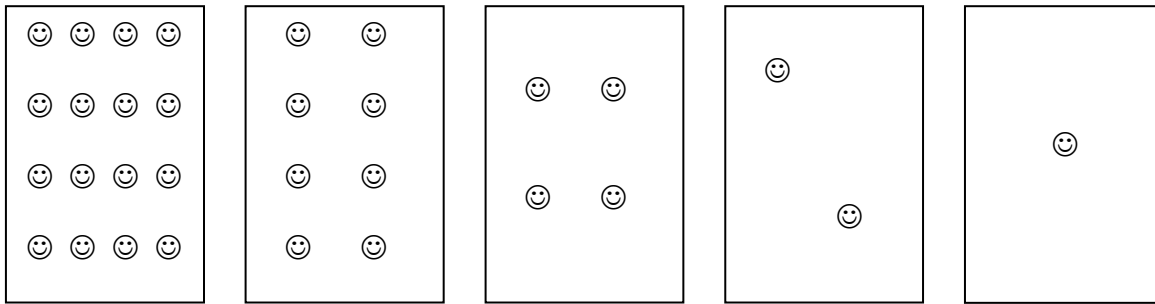


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This exercise requires 5 cards with, respectively, 1, 2, 4, 8 and 16 dots (or smiley faces etc). This idea and some of the questions that follow are based on the concept material in the manual for Computer Science Course 103, © The University of Waikato, 2003 by Professor Ian H Whitten.

If you don't have cards available you can try this online at:

<http://www.ib-computing.com/program/core/representation.html>



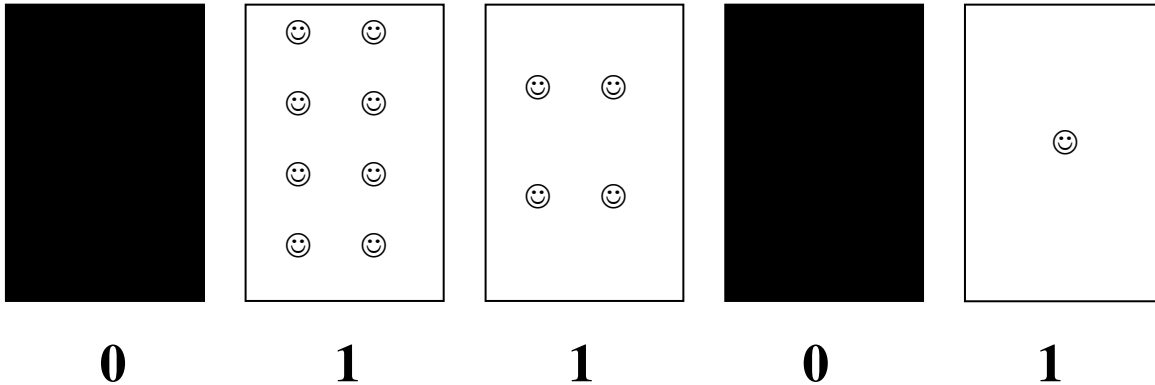
1. By flipping the cards, show how to make just 5 faces show, try 3, 12, 19. Is there more than one way to get any number?

2. What are the highest and lowest numbers you can make?

3. If we added another card, how many bits would it have? What is the biggest number we can make then?

Student name: _____

The Binary System



The zero represents whether the card is face up and whether the value of the card is to be counted. Therefore the binary number 01101 is equivalent to the decimal number 13.

4. What day of the month were you born on? Write it in decimal and binary:

We have used 5 cards here; normally binary bits are grouped in sets of 8 called a byte:

128	64	32	16	8	4	2	1
0	0	0	1	0	1	1	0

The above represents decimal 22. Notice that by convention we usually show the leading zeroes in a binary number (although we don't usually write 000022 for decimals).

5. What is the largest number we can have in this system?

We can have 2 different combinations with 1 bit (0 and 1); we can have 4 different combinations with 2 bits (00, 01, 10 and 11).

6. How many different combinations of 8 bits can we have?

Student name: _____

7. What is the relationship between the number of bits and the number of different possible combinations?
-

Negative numbers

How can negative numbers be represented? As it turns out there are many ways but probably the two most popular are **sign and magnitude** and **two's complement**. Sign and magnitude is not in the syllabus, however.

Two's Complement

In this system the most significant bit (on the left) is the same value as normal but negative:

-	64	32	16	8	4	2	1
128							
0	0	0	1	0	1	1	0

8. How do you represent -22 in this system?

-	64	32	16	8	4	2	1
128							

9. What is the most negative number you can have?

-	64	32	16	8	4	2	1
128							

10. What is the largest positive number you can have?

-	64	32	16	8	4	2	1
128							

One advantage of this system is that we can subtract binary numbers by adding a negative one to a positive one. This is quite easily done with electronic circuitry.

Student name: _____

Characters

So far we've seen how numbers can be stored in the computer but character data is important to – otherwise we could not type in text or see writing on the monitor.

Characters are often represented using ASCII (American Standard Code for Information Interchange). In this system, every character (even some that don't print) has its own binary code:

character	128	64	32	16	8	4	2	1	decimal
A	0	1	0	0	0	0	0	1	65
B	0	1	0	0	0	0	1	0	66
C	0	1	0	0	0	0	1	1	67

11. How many different characters can be stored?

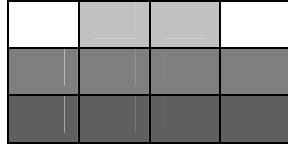
12. Why do you think characters that don't print are needed? What could they do?

13. Recently, a new system has been introduced called UNICODE which has 16 bits rather than 8; why do you think that this was needed?

Student name: _____

Pictures

We are used to the idea of **computer graphics**. How can a picture be stored in 1's and 0's? A picture in the computer is composed of **small** elements called **pixels**, these are square or rectangular and each **one** can hold only **one colour**.



If we only want to represent two colours (black and white, say) we need only 1 bit per pixel:

0	0	0	0	0	0	0	0
0	0	0	1	1	0	0	0
0	0	1	1	1	1	0	0
0	0	1	1	0	1	0	0
0	0	1	1	0	0	0	0
0	0	1	1	1	1	0	0
0	0	0	1	1	1	0	0
0	0	0	0	0	0	0	0

14. What do you “see” here? Ho, ho.

15. If we want to represent 8 shades of grey, how many bits per pixel do we need?

16. If we want to represent 256 different colours how many bits per pixel do we need?

That’s the same as a GIF image seen on a website.

Student name: _____

17. Often on modern computers 24-bit colour is used. How many different colours can be represented in this system?

Measuring Computer Memory

The term **bit** refers to the individual 1 or 0, denoted by the symbol of the single letter b.

The term **byte** refers to the standard grouping of 8bits into a single unit denoted by the single letter capital B.

Thus 4 Mb of memory is very different to 4 MB of memory.

In the decimal system, we often see the following measurements used:

Tera (T)	1,000,000,000,000
Giga (G)	100,000,000
Mega (M)	1,000,000
kilo (k)	1,000

In computing the measurements such as K are slightly different to those shown above in the table since the computer operates on the binary system.

For example 1 KB = 1024 (2^{10}) bytes; often we use the term KB as an approximation for 1000 bytes. Strictly speaking, the following terms are defined for computer memory.

Tera (T)	2^{40}
Giga (G)	2^{30}
Mega (M)	2^{20}
kilo (k)	2^{10}