

Data: The Raw Material

How can we store information in computers?

The word computer comes from the Latin *computare*, which means to calculate or add together, but computers today are more than just giant calculators. They can be a library, help us to write, find information for us, play music and even show movies. So how do they store all this information? Believe it or not, the computer uses only two things: zero and one!

What is the difference between data and information?

Data is the raw material, the numbers that computers work with. A computer converts its data into information (words, numbers and pictures) that you and I can understand.

How can numbers, letters, words and pictures be converted into zeros and ones?

In this section we will learn about binary numbers, how computers draw pictures, how fax machines work, what is the most efficient way to store lots of data, how we can prevent errors from happening and how we measure the amount of information we are trying to store.



Activity 1

Count the Dots—*Binary Numbers*

Summary

Data in computers is stored and transmitted as a series of zeros and ones. How can we represent words and numbers using just these two symbols?

Curriculum Links

- ✓ Mathematics: Number – Exploring numbers in other bases. Representing numbers in base two.
- ✓ Mathematics: Algebra – Continue a sequential pattern, and describe a rule for this pattern. Patterns and relationships in powers of two.

Skills

- ✓ Counting
- ✓ Matching
- ✓ Sequencing

Ages

- ✓ 6 and up

Materials

- ✓ You will need to make a set of five binary cards (see page 7) for the demonstration.
A4 cards with smiley face sticker dots work well.

Each student will need:

- ✓ A set of five cards.
Copy Photocopy Master: Binary numbers (page 7) onto card and cut out.
- ✓ Worksheet Activity: Binary numbers (page 6)

There are optional extension activities, for which each student will need:

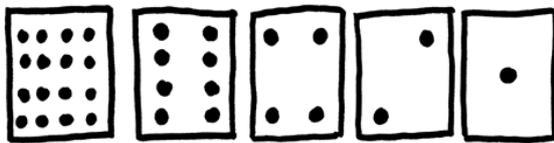
- ✓ Worksheet Activity: Working with binary (page 8)
- ✓ Worksheet Activity: Sending secret messages (page 9)
- ✓ Worksheet Activity: Email and modems (page 10)
- ✓ Worksheet Activity: Counting higher than 31 (page 11)
- ✓ Worksheet Activity: More on binary numbers (page 12)

Binary Numbers

Introduction

Before giving out the worksheet on page 6, it can be helpful to demonstrate the principles to the whole group.

For this activity, you will need a set of five cards, as shown below, with dots on one side and nothing on the other. Choose five students to hold the demonstration cards at the front of the class. The cards should be in the following order:



Discussion

As you give out the cards (from right to left), see if the students can guess how many dots are on the next card. What do you notice about the number of dots on the cards? (Each card has twice as many as the card to its right.)

How many dots would the next card have if we carried on to the left? (32) The next...? (64)

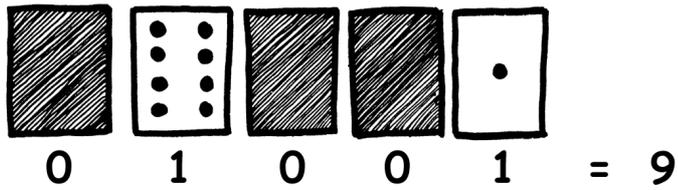
We can use these cards to make numbers by turning some of them face down and adding up the dots that are showing. Ask the students to show 6 dots (4-dot and 2-dot cards), then 15 (8-, 4-, 2- and 1-dot cards), then 21 (16, 4 and 1)... The only rule is that a card has to be completely visible, or completely hidden.

What is the smallest number of dots possible? (They may answer one, but it's zero).

Now try counting from zero onwards.

The rest of the class needs to look closely at how the cards change to see if they can see a pattern in how the cards flip (each card flips half as often as the one to its right). You may like to try this with more than one group.

When a binary number card is **not** showing, it is represented by a zero. When it **is** showing, it is represented by a one. This is the binary number system.



Ask the students to make 01001. What number is this in decimal? (9) What would 17 be in binary? (10001)

Try a few more until they understand the concept.

There are five optional follow-up extension activities, to be used for reinforcement. The students should do as many of them as they can.

Worksheet Activity: Binary Numbers

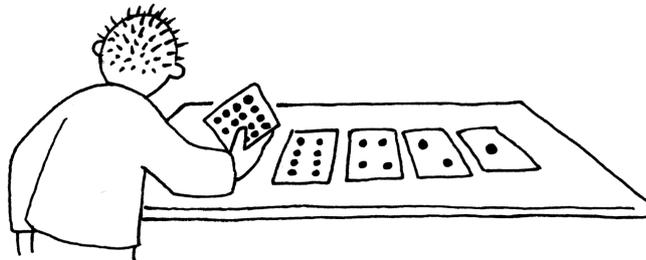
Learning how to count

So, you thought you knew how to count? Well, here is a new way to do it!

Did you know that computers use only zero and one? Everything that you see or hear on the computer—words, pictures, numbers, movies and even sound is stored using just those two numbers! These activities will teach you how to send secret messages to your friends using exactly the same method as a computer.

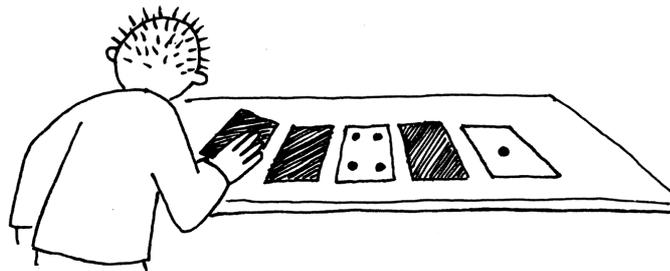
Instructions

Cut out the cards on your sheet and lay them out with the 16-dot card on the left as shown here:



Make sure the cards are placed in exactly the same order.

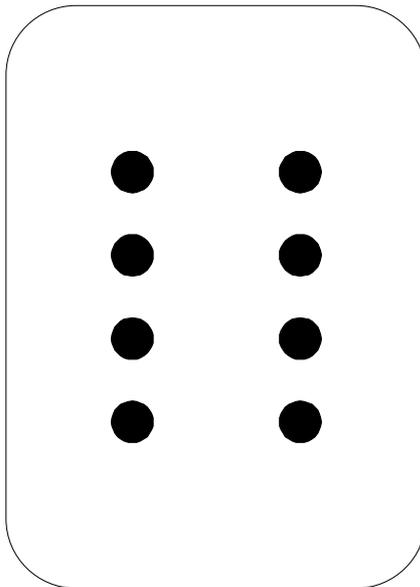
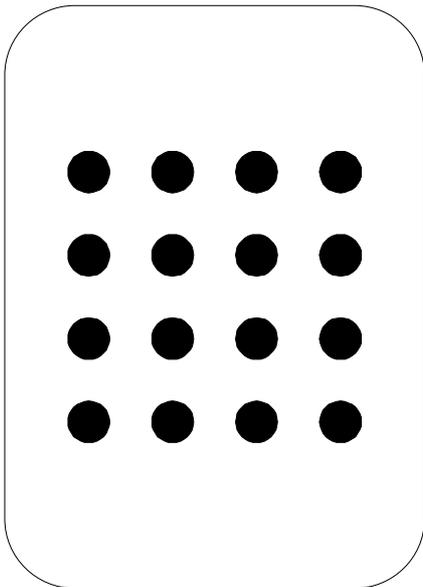
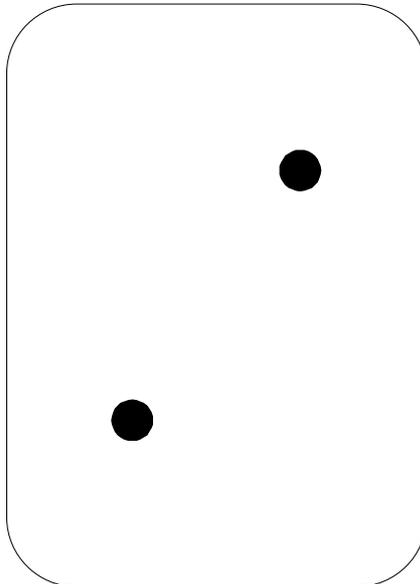
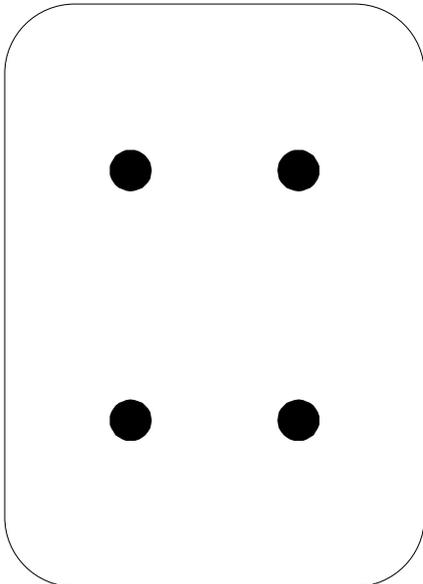
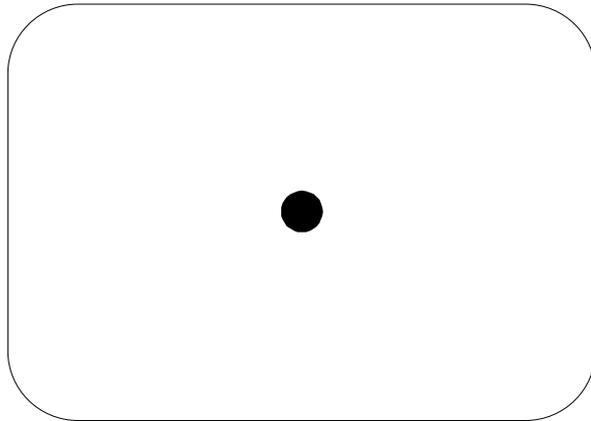
Now flip the cards so exactly 5 dots show—keep your cards in the same order!



Find out how to get 3, 12, 19. Is there more than one way to get any number? What is the biggest number you can make? What is the smallest? Is there any number you can't make between the smallest and biggest numbers?

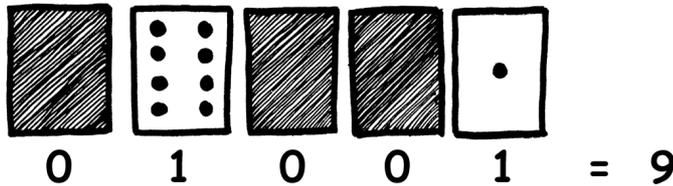
Extra for Experts: Try making the numbers 1, 2, 3, 4 in order. Can you work out a logical and reliable method of flipping the cards to increase any number by one?

Photocopy Master: Binary Numbers



Worksheet Activity: Working With Binary

The binary system uses **zero** and **one** to represent whether a card is face up or not. **0** shows that a card is hidden, and **1** means that you can see the dots. For example:



Can you work out what **10101** is? What about **11111**?

What day of the month were you born? Write it in binary. Find out what your friend's birthdays are in binary.

Try to work out these coded numbers:

$$\begin{matrix} \boxtimes & \checkmark & \boxtimes & \boxtimes & \checkmark \\ \hline (\checkmark=1, \boxtimes=0) \end{matrix} =$$

$$\begin{matrix} \uparrow & \downarrow & \uparrow \\ \hline (\uparrow=1, \downarrow=0) \end{matrix} =$$

$$\begin{matrix} \bigcirc & \bigcirc & \bigcirc & \bigcirc & \bigcirc \\ \hline (\odot=1, \bigcirc=0) \end{matrix} =$$

$$\begin{matrix} \uparrow & \downarrow \\ \hline (\uparrow=1, \downarrow=0) \end{matrix} =$$

$$\begin{matrix} \text{☹} \\ \hline (\text{☺}=1, \text{☹}=0) \end{matrix} =$$

$$\begin{matrix} \text{👍} & \text{👎} & \text{👍} & \text{👎} \\ \hline (\text{👍}=1, \text{👎}=0) \end{matrix} =$$

$$\begin{matrix} + & + & \times & + \\ \hline (+=1, \times=0) \end{matrix} =$$

$$\begin{matrix} \cup & \cup & \cup & \cup & \cup \\ \hline (\cup=1, \cup=0) \end{matrix} =$$

$$\begin{matrix} \blacktriangle & \blacktriangledown & \blacktriangle & \blacktriangledown & \blacktriangledown \\ \hline (\blacktriangle=1, \blacktriangledown=0) \end{matrix} =$$

$$\begin{matrix} \spadesuit & \spadesuit & \spadesuit & \spadesuit & \spadesuit \\ \hline (\spadesuit=1, \clubsuit=0) \end{matrix} =$$

Extra for Experts: Using a set of rods of length 1, 2, 4, 8 and 16 units show how you can make any length up to 31 units. Or you could surprise an adult and show them how they only need a balance scale and a few weights to be able to weigh those heavy things like suitcases or boxes!

Worksheet Activity: Counting higher than 31

Look at the binary cards again. If you were going to make the next card in the sequence, how many dots would it have? What about the next card after that? What is the rule that you are following to make your new cards? As you can see, only a few cards are needed to count up to very big numbers.

If you look at the sequence carefully, you can find a very interesting relationship:

1, 2, 4, 8, 16...

Try adding: $1 + 2 + 4 = ?$ What does it come to?

Now try $1 + 2 + 4 + 8 = ?$

What happens if you add all the numbers up from the beginning?

Have you ever heard of “let your fingers do the walking”? Well now you can let your fingers do the counting, but you can get much higher than ten—no, you don’t have to be an alien! If you use the binary system and let each finger on one hand represent one of the cards with dots you can count from 0–31. That’s 32 numbers. (Don’t forget that zero is a number too!)

Try counting in order using your fingers. If a finger is up it is a one, and if it is down it is a zero.

You can actually get from 0–1023 if you use both hands! That’s 1024 numbers!

If you had really bendy toes (now you would have to be an alien) you could get even higher. If one hand can be used to count 32 numbers, and two hands can count to $32 \times 32 = 1024$ numbers, what is the biggest number Miss Flexi-Toes can reach?

