Worksheet Activity: Binary Numbers

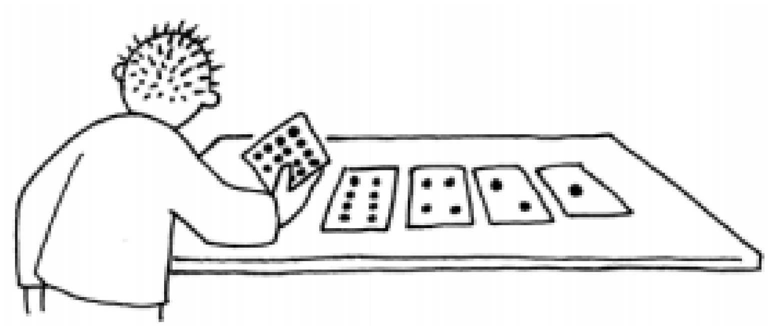
Learning how to count

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.

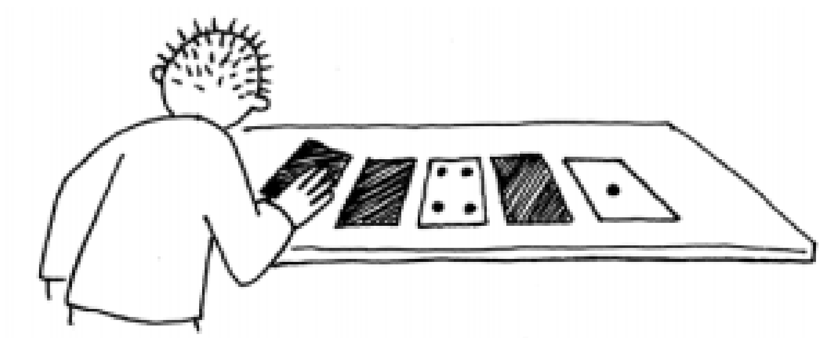
Instructions

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!

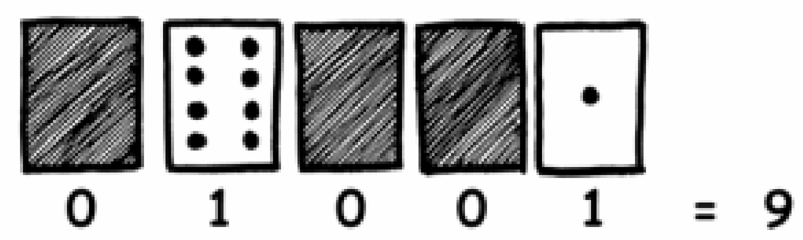


Find out how to get 3, 12, 19. Is there more than one way to get any number? What is the biggest number you can make? What is the smallest? Is there any number you can't make between the smallest and biggest numbers?

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?

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:

☒☑☒☒☑ =
(☑=1, ☒=0)

⇧⇩⇧ =
(⇧=1, ⇩=0)

○○○○○ =
(⊙=1, ○=0)

📫📪 =
(📫=1, 📪=0)

☹ =
(☺=1, ☹=0)

👍👎👍👎 =
(👍=1, 👎=0)

✚✚✖✚ =
(✚=1, ✖=0)

↻↺↺↺↻ =
(↻=1, ↺=0)

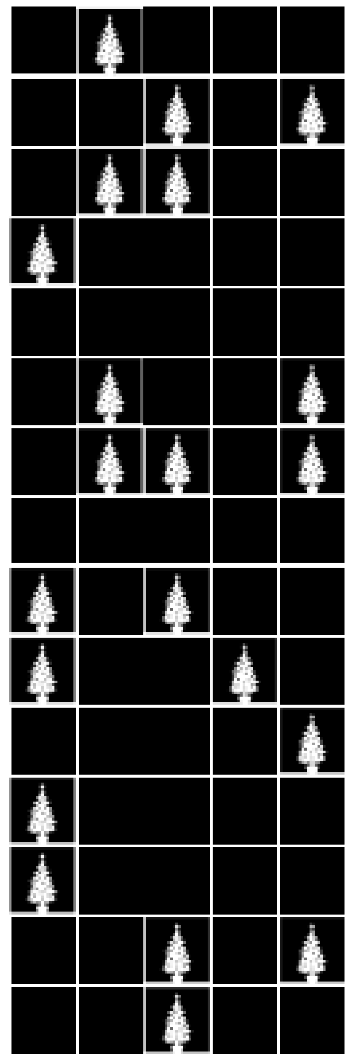
▲▼▲▼▼ =
(▲=1, ▼=0)

♠♠♠♠♠ =
(♠=1, ♣=0)

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: Sending Secret Messages

Tom is trapped on the top floor of a department store. It's just before Christmas and he wants to get home with his presents. What can he do? He has tried calling, even yelling, but there is no one around. Across the street he can see some computer person still working away late into the night. How could he attract her attention? Tom looks around to see what he could use. Then he has a brilliant idea—he can use the Christmas tree lights to send her a message! He finds all the lights and plugs them in so he can turn them on and off. He uses a simple binary code, which he knows the woman across the street is sure to understand. Can you work it out?



1	2	3	4	5	6	7	8	9	10	11	12	13
a	b	c	d	e	f	g	h	i	j	k	l	m
14	15	16	17	18	19	20	21	22	23	24	25	26
n	o	p	q	r	s	t	u	v	w	x	y	z

Worksheet Activity: More on Binary Numbers

1. Another interesting property of binary numbers is what happens when a zero is put on the right hand side of the number. If we are working in base 10 (decimal), when you put a zero on the right hand side of the number, it is multiplied by 10. For example, 9 becomes 90, 30 becomes 300.

   But what happens when you put a 0 on the right of a binary number? Try this:

   $$\underset{(9)}{\mathbf{1001}} \rightarrow \underset{(?)}{\mathbf{10010}}$$

   Make up some others to test your hypothesis. What is the rule? Why do you think this happens?

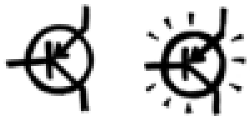
2. Each of the cards we have used so far represents a 'bit' on the computer ('bit' is short for '**b**inary dig**it**'). So our alphabet code we have used so far can be represented using just five cards, or 'bits'. However a computer has to know whether letters are capitals or not, and also recognise digits, punctuation and special symbols such as **$** or **~**.

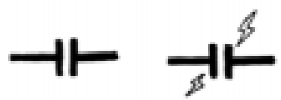
   Go and look at a keyboard and work out how many characters a computer has to represent. So how many bits does a computer need to store all the characters?

   Most computers today use a representation called ASCII (**A**merican **S**tandard **C**ode for **I**nformation **I**nterchange), which is based on using this number of bits per character, but some non-English speaking countries have to use longer codes.

What’s it all about?

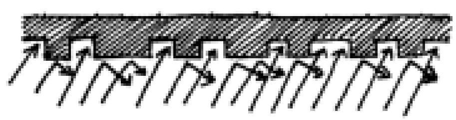
Computers today use the binary system to represent information. It is called binary because only two different digits are used. It is also known as base two (humans normally use base 10). Each zero or one is called a *bit* (**b**inary dig**it**). A bit is usually represented in a computer’s main memory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





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.

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.



One bit on its own can’t represent much, so they are usually grouped together in groups of eight, which can represent numbers from 0 to 255. A group of eight bits is called a byte.

The speed of a computer depends on the number of bits it can process at once. For example, a 32-bit computer can process 32-bit numbers in one operation, while a 16-bit computer must break 32-bit numbers down into smaller pieces, making it slower.

Ultimately bits and bytes are all that a computer uses to store and transmit numbers, text, and all other information. In some of the later activities we will see how other kinds of information can be represented on a computer.