

# Data: The Raw Material

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## 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.



# Colour by Numbers

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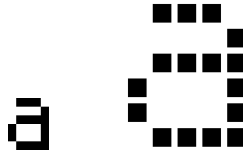
## Introduction

### Discussion Questions

1. What do facsimile (fax) machines do?
2. In what situations would computers need to store pictures? (A drawing program, a game with graphics, or a multi-media system.)
3. How can computers store pictures when they can only use numbers?

(You may like to arrange for the students to send and/or receive faxes as a preparation for this activity)

### Demonstration using projection



Computer screens are divided up into a grid of small dots called *pixels* (picture elements).

In a black and white picture, each pixel is either black or white.

The letter “a” has been magnified above to show the pixels. When a computer stores a picture, all that it needs to store is which dots are black and which are white.

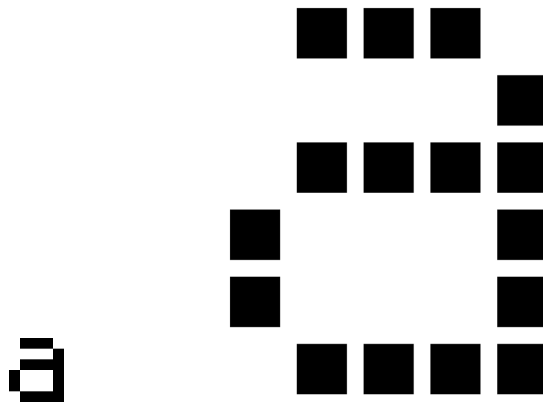
	■	■	■		1, 3, 1
				■	4, 1
	■	■	■	■	1, 4
■				■	0, 1, 3, 1
■				■	0, 1, 3, 1
	■	■	■	■	1, 4

The picture above shows us how a picture can be represented by numbers. The first line consists of one white pixel, then three black, then one white. Thus the first line is represented as 1, 3, 1.

The first number always relates to the number of white pixels. If the first pixel is black the line will begin with a zero.

The worksheet on page 20 gives some pictures that the students can decode using the method just demonstrated.

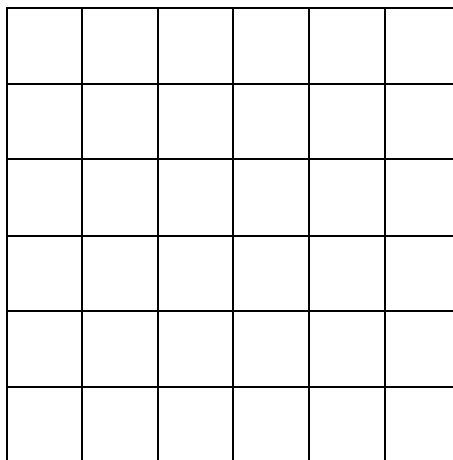
# Colour by numbers



▲ A letter "a" from a computer screen and a magnified view showing the pixels that make up the image

	■	■	■		1, 3, 1
				■	4, 1
	■	■	■	■	1, 4
■				■	0, 1, 3, 1
■				■	0, 1, 3, 1
	■	■	■	■	1, 4

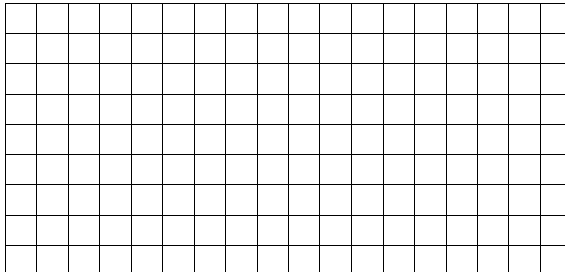
▲ The same image coded using numbers



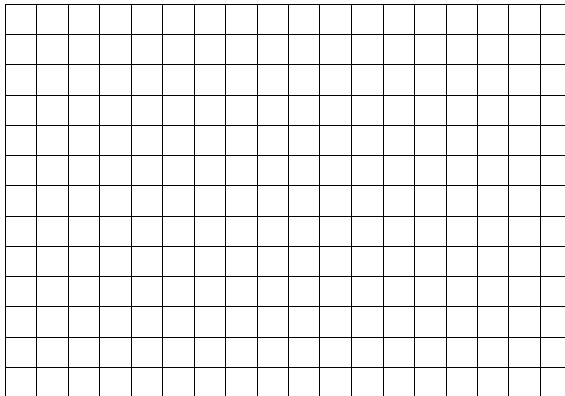
▲ Blank grid (for teaching purposes)

## Worksheet Activity: Kid Fax

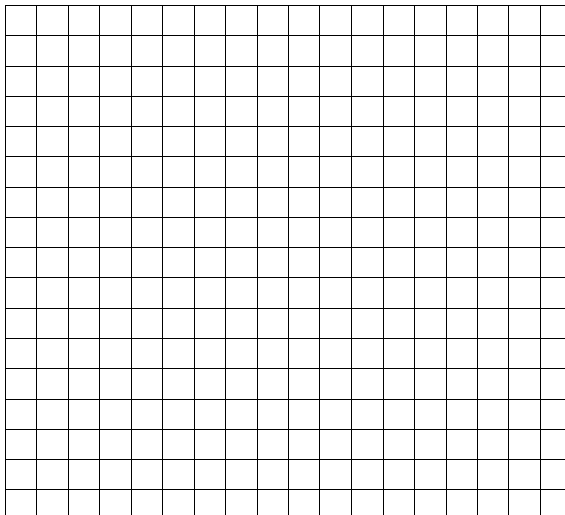
The first picture is the easiest and the last one is the most complex. It is easy to make mistakes and therefore a good idea to use a pencil to colour with and have a rubber handy!



4, 11  
 4, 9, 2, 1  
 4, 9, 2, 1  
 4, 11  
 4, 9  
 4, 9  
 5, 7  
 0, 17  
 1, 15



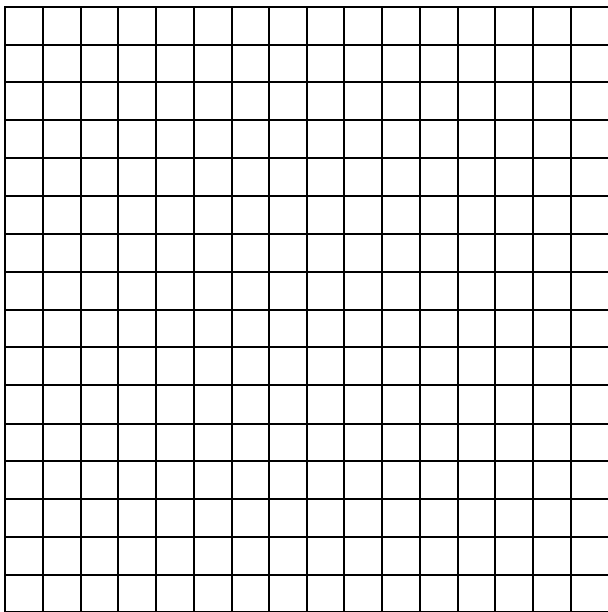
6, 5, 2, 3  
 4, 2, 5, 2, 3, 1  
 3, 1, 9, 1, 2, 1  
 3, 1, 9, 1, 1, 1  
 2, 1, 11, 1  
 2, 1, 10, 2  
 2, 1, 9, 1, 1, 1  
 2, 1, 8, 1, 2, 1  
 2, 1, 7, 1, 3, 1  
 1, 1, 1, 1, 4, 2, 3, 1  
 0, 1, 2, 1, 2, 2, 5, 1  
 0, 1, 3, 2, 5, 2  
 1, 3, 2, 5



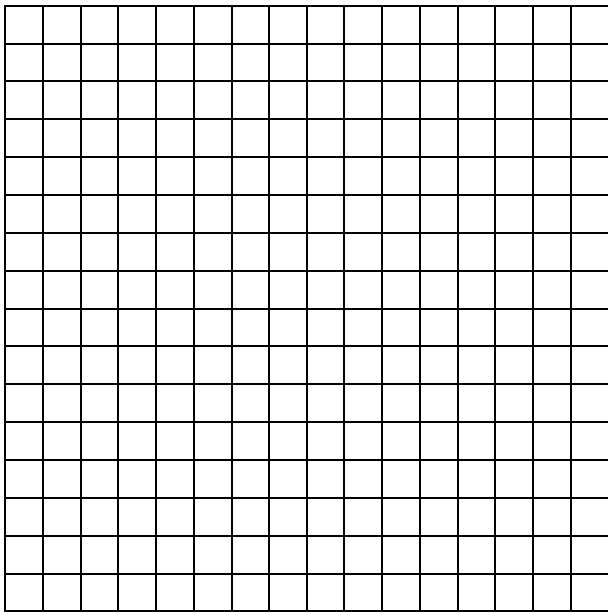
6, 2, 2, 2  
 5, 1, 2, 2, 2, 1  
 6, 6  
 4, 2, 6, 2  
 3, 1, 10, 1  
 2, 1, 12, 1  
 2, 1, 3, 1, 4, 1, 3, 1  
 1, 2, 12, 2  
 0, 1, 16, 1  
 0, 1, 6, 1, 2, 1, 6, 1  
 0, 1, 7, 2, 7, 1  
 1, 1, 14, 1  
 2, 1, 12, 1  
 2, 1, 5, 2, 5, 1  
 3, 1, 10, 1  
 4, 2, 6, 2  
 6, 6

# Worksheet Activity: Make Your Own Picture

Now that you know how numbers can represent pictures, why not try making your own coded picture for a friend? Draw your picture on the top grid, and when you've finished, write the code numbers beside the bottom grid. Cut along the dotted line and give the bottom grid to a friend to colour in. (Note: you don't have to use the whole grid if you don't want to—just leave some blank lines at the bottom if your picture doesn't take up the whole grid.)



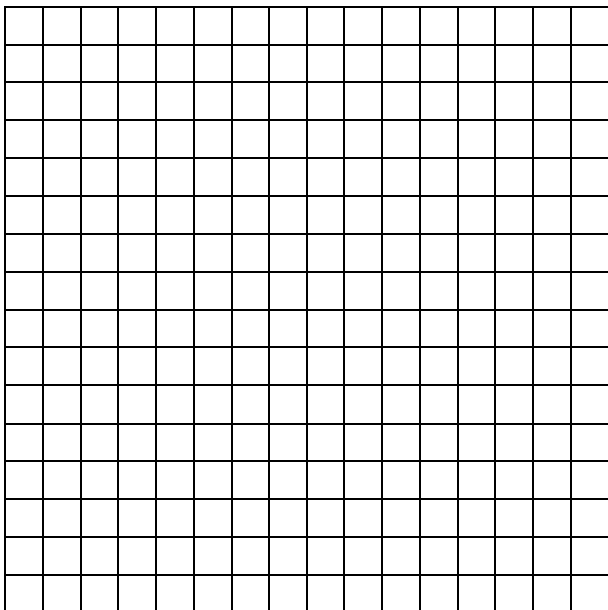
15 horizontal lines for writing code numbers.



15 horizontal lines for writing code numbers.

# Worksheet Activity: Make Your Own Picture

**Extra for Experts:** If you want to produce coloured images you can use a number to represent the colour (e.g. 0 is black, 1 is red, 2 is green etc.) Two numbers are now used to represent a run of pixels: the first gives the length of the run as before, and the second specifies the colour. Try making a coloured picture for a friend. Don't forget to let your friend know which number stands for which colour!



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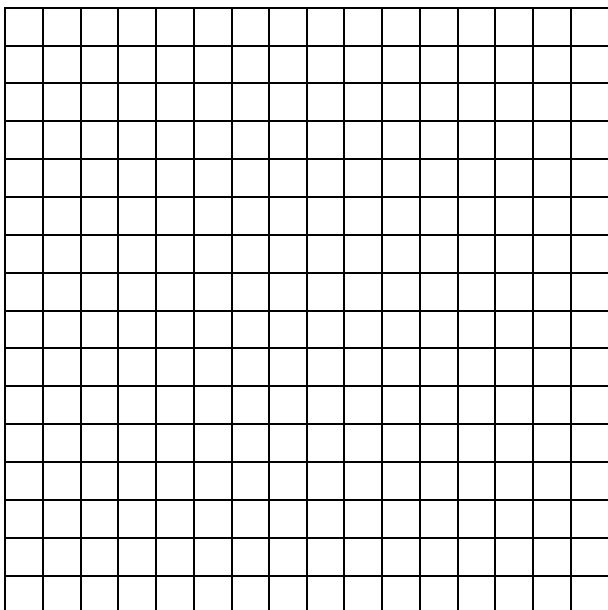
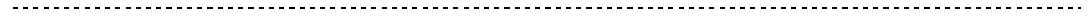
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### **Variations and Extensions**

1. Try drawing with a sheet of tracing paper on top of the grid, so that the final image can be viewed without the grid. The image will be clearer.
2. Instead of colouring the grid the students could use squares of sticky paper, or place objects, on a larger grid.

### **Discussion Point**

There is usually a limit to the length of a run of pixels because the length is being represented as a binary number. How would you represent a run of twelve black pixels if you could only use numbers up to seven? (A good way is to code a run of seven black pixels, followed by a run of zero white, then a run of five black.)



# What's it all about?

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A fax machine is really just a simple computer that scans a black and white page into about  $1000 \times 2000$  pixels, which are sent using a modem to another fax machine, which prints the pixels out on a page. Often fax images have large blocks of white (e.g. margins) or black pixels (e.g. a horizontal line). Colour pictures also have a lot of repetition in them. To save on the amount of storage space needed to keep such images programmers can use a variety of compression techniques. The method used in this activity is called 'run-length coding', and is an effective way to compress images. If we didn't compress images it would take much longer to transmit pictures and require much more storage space. This would make it infeasible to send faxes or put photos on a web page. For example, fax images are generally compressed to about a seventh of their original size. Without compression they would take seven times as long to transmit!

Photographs and pictures are often compressed to a tenth or even a hundredth of their original size (using a related techniques such as JPEG, GIF and PNG). This allows many more images to be stored on a disk, and it means that viewing them over the web will take a fraction of the time.

A programmer can choose which compression technique best suits the images he or she is transmitting.



# Solutions and hints

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## Answers to Kid Fax Worksheet

