Chapter 5: Input Devices

Learning objectives

By the end of this chapter you will:

- be able to define the term 'input device'
- be able to describe how a keyboard and a mouse are used
- be able to describe how 2D and 3D scanners work, including barcode readers and quick response (QR) code readers
- be able to describe how digital cameras capture and store images
- be able to describe how touch screens and interactive whiteboards are used
- be able to describe how microphones record sound and how they are used
- be able to describe how input devices are used in real-life scenarios.

5.01 What is an input device?

An input device is a **hardware** device that allows a user to enter data into a computer system. Input devices can be manual or automatic. Manual input devices need a user to physically enter the data into a computer system. For example, a keyboard requires a user to press the keys to enter data into the computer. An automatic input device is one that will automatically read data and input it into a computer system. For example, a temperature sensor can take the temperature of a room and automatically input it into a computer system without any user interaction.

KEY TERM

Hardware – the physical components of a computer.

There are a number of input devices that we need to be aware of and we need to be able to explain how each of them works.

TEST YOURSELF

Why would we want computers to read data automatically into a computer system for us?

SYLLABUS CHECK

Describe the principles of operation (how each device works) of a range of input devices including 2D and 3D scanners, barcode readers, digital cameras, keyboards, mice, touch screens, microphones.

Describe how these principles are applied to real-life scenarios, for example: scanning of passports at airports, barcode readers at supermarket checkouts, and touch screens on mobile devices.

5.02 Keyboard

Keyboards are one of the main and most common methods of entering data into a computer. They have a set of keys that can be pressed to enter the data. The keys will generally allow entry of letters, numbers and symbols that are used in our everyday language. They can also

Figure 5.01 A keyboard is a hardware device used to input data into a computer system

have special command and function keys that are programmed to perform specific tasks, as well as arrow keys that can be used to navigate the computer system.

More modern devices can have an on-screen keyboard. This is similar to a normal keyboard, but the keys are not keys that are physically pressed down. They are keys that are displayed on a screen and when pressure is applied to a 'key' they will enter the data of that key. They are created by **software** rather than being a hardware device. On-screen keyboards can also be known as virtual keyboards.

KEY TERM

Software – programs and instructions run on a computer.

Figure 5.02 An on-screen keyboard is a software device used to input data into a computer system

Table 5.01

Advantages of a keyboard	Disadvantages of a keyboard
Keyboards are very simple to use	It is easy to make a mistake when using a keyboard to input data
If a person is trained to type fast then inputting data using a keyboard can be very efficient	If a person is not trained to type fast then inputting data using a keyboard can be slow

TEST YOURSELF

Can you think of three different devices that would make use of an on-screen keyboard?

There is a further type of keyboard available to input data, which is called a 'concept keyboard'. A concept keyboard is generally a surface that is flat and has a grid of buttons on it. Each button in a concept keyboard can be programmed do a specific task. An overlay can then be placed over the buttons to indicate the tasks that they perform.

A concept keyboard can be used where there is a limited amount of data that needs to be entered into a system, for example in a fast food restaurant. Each item of the menu could be assigned to a different button, with a button to total the order when complete. This way each order can be input quickly, increasing the speed at which orders can be taken.

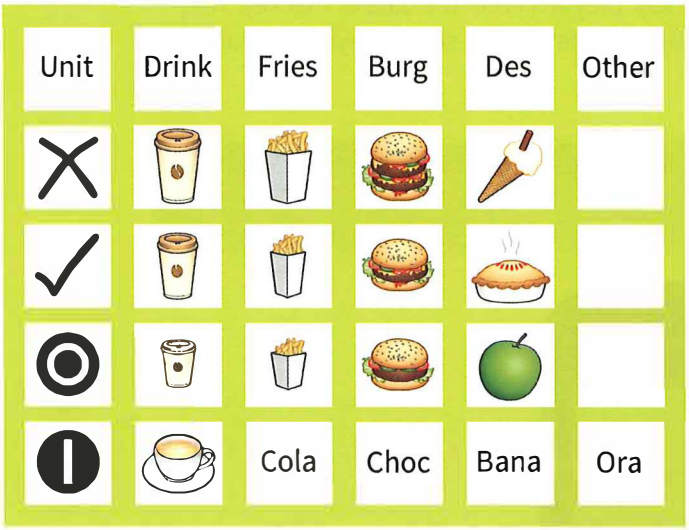

Figure 5.03 An example of what a concept keyboard may look like

5.03 Mouse

A mouse is an input device that is used to control a pointer or a cursor on a screen. It enables a user to move the pointer to navigate around the screen. The user can then use the buttons that are generally part of a mouse to click items on the screen. A mouse will normally have two buttons at the top. The left button will often allow a user to click on an item and the right button, when clicked, will normally open up a menu. A mouse could also have a scroll wheel in the centre of the two buttons that can be used to scroll through documents and webpages.

An older style of mouse will probably have a ball in the underside of it. This rolls against internal rollers in the mouse to move the pointer in the direction intended. A newer style of mouse uses an optical laser that tracks the movement of the mouse across a surface to move the pointer in the direction intended.

Figure 5.04 This older style of mouse uses a roller ball to move the pointer

Figure 5.05 This newer style of mouse uses an optical laser to move the pointer

Table 5.02

Advantages of a mouse	Disadvantages of a mouse
A mouse is very simple to use	The user needs a flat surface next to the computer to move the mouse around in. If this space is limited it can restrict the use of a mouse
A mouse lets the user efficiently navigate around a screen	If the roller ball gets clogged with dirt, or if dirt covers the optical laser, this can stop a mouse working properly

There are two alternative pointing devices: a trackball and a foot mouse. A trackball is used in the same way as a mouse but it is useful where desk space is limited. The user rotates the ball whilst the main body part stays still. It has buttons like a standard mouse. The trackball mouse allows users to move and select items on the screen and is often used in computer-aided design (CAD) especially for 3D design, for its increased precision compared to a mouse. Trackballs have also been adapted for those users who have limited hand movement in the form of a foot mouse.

TEST YOURSELF

CAD is a type of software that is used to create precise drawings. CAD can be used to create 2D drawings and 3D models and it is used by people such as architects and engineers.

Figure 5.06 A trackball

Figure 5.07 A foot mouse

5.04 Scanners

2D scanner

Two-dimensional (2D) scanners can be used to scan a physical document, for example a printed image or a text document, from a flat (two-dimensional) surface. 2D scanners can be used to convert these documents into a digital format that can be used on a computer.

A scanner works by shining light into the surface of the document. The light source moves across the document and the reflected light is captured onto a light-sensitive device using mirrors and lenses. The captured image is converted into a digital signal for input to a computer.

Most documents that are scanned will be stored as an image. However, a scanned document can be manipulated and stored in different formats. Text can be converted to a text file using **optical character recognition (OCR)** software, so that it can be edited. However, this is not very reliable and can be prone to errors; a converted document is often full of mistakes.

A 2D scanner can also be used with **optical mark recognition (OMR).** With OMR, the scanner scans a page and the OMR software notes where marks have been made on it. The computer records the marks' positions as inputs. This method is widely used to automatically mark multiple-choice question papers. It is also used in situations where it is preferable to avoid the user having to handwrite text, for example recording the numbers on a lottery ticket.

KEY TERM

Optical character recognition (OCR) – a process where text on a scanned document is recognised and converted to digital text.

Optical mark recognition (OMR) – a process where scanned marks on a page are automatically converted to inputs.

There are two main types of 2D scanner: a flatbed scanner and a handheld scanner.

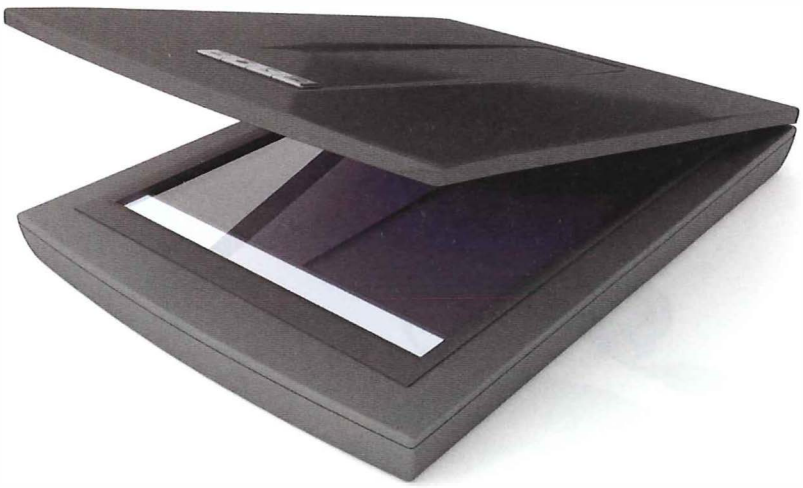

Figure 5.08 A flatbed scanner scans a document automatically

A flatbed scanner is the most popular type of 2D scanner. With a flatbed scanner an image is placed on the scanner bed, this is the base of the scanner. The scanner moves the light and

sensor itself and scans the whole image automatically. This is the type of scanner that you may have used at school.

A handheld scanner is an alternative type of scanner. With a handheld scanner the light and sensor must be manually pushed along the image to scan it. Handheld scanners are normally used to scan smaller images.

Figure 5.09 A document must be manually scanned with a handheld scanner

TEST YOURSELF

Think of two examples where a handheld scanner would be more suitable than a flatbed scanner?

Table 5.03

Advantages of a scanner	Disadvantages of a scanner
Flatbed scanners are able to produce digital copies of documents that are quite high in quality	Scanned documents can use a lot of memory space, especially if they are scanned photographs
Digital copies created by a 2D scanner can be edited with software such as graphics creators, photograph editors and word processors	Although the scanned digital copy can be quite high in quality, it is not likely to be as high quality as the original, especially if it is an image or photograph
A digital copy of a scanned document could be attached to an email or included in another digital document	If the quality of the original document is not very good then the quality of the scanned image is likely to be even worse

3D scanner

A three-dimensional (3D) scanner is used to produce a 3D model rather than a 2D image. A 3D scanner will scan a 3D object using a laser or a light source (or sometimes X-rays). It will measure and input the geometry of an object into a computer system and create a model of it. This model could be a digital model or, if used in conjunction with a 3D printer, a physical model or replica.

3D scanners are now used as a security measure in airports. An airport traveller will step into the 3D scanner, their body will be scanned and a 3D image of their form will be displayed for inspection to see if they are carrying any hidden goods or weapons on their body.

Figure 5.10 A 3D scanner in an airport used as a security check

Biometric devices also make use of scanners. They are used to identify people. A person's biological features are scanned, for example their retina, their fingerprint or their face, and the data from these is stored in a computer system. When a person's biological features are scanned again, a biometric device will look for a match in the computer system.

KEY TERM

Biometric device – device that recognises human physical characteristics, such as fingerprints.

In many airports today biometric data can be used to allow users to enter into a country. The biometric data is stored a chip in a person's passport. This passport can then be scanned to input the person's biometric data. The person will step into a biometric scanner that will scan their biometric features to see if they match those stored in the chip in the passport.

The biometric data used in this situation is generally facial recognition software. The facial recognition software will take in a lot of measurements about a person's face. For example

the distance between a person's eyes and the length of a person's nose will be stored on the chip in the passport. A facial scanner in an airport will use facial recognition software to see if the measurements of the face it is scanning match the measurements stored on the passport chip. This kind of passport is referred to as an electronic passport, or e-passport for short.

To learn more about different types of biometric devices see Chapter 9.

Figure 5.11 An e-passport

Barcodes

Barcodes were developed in the 1970s to help people in the retail trade. Cashiers were starting to get health problems, such as repetitive strain injury (RSI), from entering all the prices of a customer's shopping basket for hours on end. A method needed to be developed that would allow the price of a shopping item to be input into the cash register without continuous typing by the cashier. This led to the development of the barcode and barcode scanner.

Barcodes are represented by black vertical bars with spaces (white vertical bars) between them. A barcode reader is an input device with software that converts data that is pre-coded into a barcode. The barcode reader scans the barcode and translates it into a number. Barcodes are printed on every product sold and bought. Since the data is scanned and read automatically, barcode readers provide a fast and reliable method of entering data.

When a barcode is scanned, it is illuminated with a red light called an illuminator. A **sensor** inside the reading device detects the light reflected back from the barcode. The signal received is an **analogue** signal. The sensor converts the analogue signal into a **digital** signal. The digital signal is then decoded by a decoder. Once decoded the signal is sent to a computer. This could also be our mobile phone.

KEY TERM

Sensor – a device that records physical inputs.

Analogue – a signal, or data, that constantly varies.

Digital – a signal, or data that consists of two states, 1 or 0.

In a supermarket, the barcode data read is matched with the product's information, such as the product name, code and manufacturer. The price of the product is not stored in the

barcode; it is stored in the computer system and is matched up to the product details when the product is scanned. This is so that if the price of a product changes, all the barcodes don't need to be changed on a product, the price can just be changed in the computer system. Data such as the price of a product will be stored in a database.

To learn more about databases see Chapter 14.

The barcode data is used to form the customer's bill and also to assist in stock checks. Once a product is sold, the stock figure a store has recorded for that product can be automatically reduced by one, so that a fairly accurate amount of that product in stock can be recorded. This stock figure may not be completely accurate as it will not account for any stock that is stolen from the shop. Barcode readers can either be flatbed or handheld scanners.

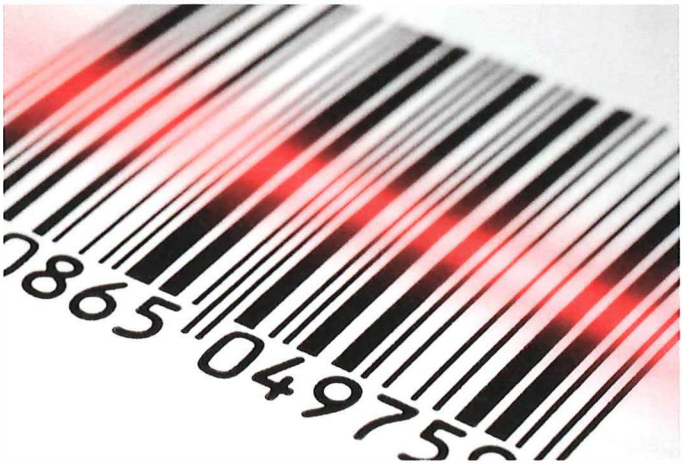

Figure 5.12 A barcode being scanned

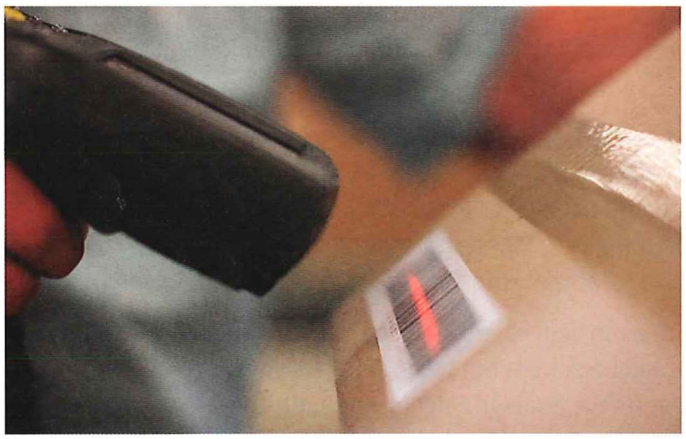

Figure 5.13 A handheld barcode scanner

Table 5.04

Advantages of a barcode	Disadvantages of a barcode
A barcode is a very efficient method of entering a product's details to find out its price	If the barcode is damaged, not printed clearly, or rubbed away in part, it may not scan properly
A barcode can be used to help keep a record of stock levels for a product	If the barcode data has not been recorded in the computer system, the barcode scanner will not be able to find it

QR codes

A quick response (QR) code is a 2D square barcode. They look like Figure 5.14:

Figure 5.14 Quick response (QR) code

While there are a few claims to the origin of the QR code, it is most commonly believed to have been invented by Denso-Wave (part of the Toyota group) in 1994 to track parts when manufacturing vehicles.

QR codes are made up of lots of black and white squares. Each black or white square is called a module. You will notice that the example QR code in Figure 5.14 has three larger squares in three of its corners. These squares tell a QR code reader where the edges of the QR code are.

A normal barcode is one-dimensional; it stores data in a line of black and white bars. QR codes are two-dimensional; they store data both horizontally and vertically. The means that they can also be read horizontally and vertically by a QR code reader. A barcode can normally store up to 30 numbers, while a QR code can normally store about 7000. It is their ability to store this amount of data that makes QR codes useful for creating links and storing things.

To read a QR code we need a QR code reader. This can be a simple imaging device such as the camera on a smartphone. The imaging device coupled with QR code reading software will allow us to create a QR code reader. When we scan the QR code with a QR code reader it will show what was encoded into it. This could mean we are directed to a website that will open or a message could be displayed. QR codes can be coded so they link to many things, for example, a website, a video or a social networking profile. They can also be used to store data such as a message or a telephone number. Using a QR code reader, try reading the QR code in Figure 5.14.

Anyone can make a QR code. There are lots of websites we can use to make them such as www.qrstuff.com and www.qr-code-generator.com. These website are QR code generators. We can enter the data we want to be encoded into a QR code and the generator will create a QR code for us.

QR codes are very clever as they have an error correction method built into them, called the 'Reed Solomon method'. This means that even if the QR code has a couple of misprinted modules or a couple of modules are covered up, the QR code can normally still be read.

TEST YOURSELF

Find out more about how the Reed Solomon method works as an error correction method.

People and companies use QR codes for a large variety of reasons. They are an excellent marketing tool. They can be placed in an advert allowing the audience to scan the code leading them to more product information. QR codes are used on business cards to link a person to further information about a business, such as their website, or a person's full resume. They can also be used in museums or on wildlife and nature trails to provide the audience with further information should they want it.

Table 5.05

Advantages of a QR code	Disadvantages of a QR code
QR codes are a very efficient method of storing information and linking to it	QR codes are not yet as common as barcodes. There may be some people that do not know what they are for
QR codes can store a variety of information including links to websites, images, videos and messages	If QR codes are used for advertising or for distributing information, people need to have the ability to read them, such as using a smartphone
Even if some areas of a QR code are missing or covered up, the code can often still be read	

5.05 Digital camera

Steven Sasson, an engineer at Kodak, invented and built the first known digital camera in 1975. A digital camera **encodes** digital images and videos and stores them for viewing and later use. Prior to this cameras were analogue devices and would use camera film to capture images. This film would need to be processed in a dark room to be able to view the images taken with the camera.

KEY TERM

Encoding – the process of converting data or information to a particular form.

With a digital camera images can be viewed immediately. The image is stored in built-in memory or on an SD card and can be displayed on a screen. Most cameras sold since the early 2000s have been digital cameras. Many mobile phones now have a digital camera built into them.

Digital cameras capture an image by recording the image via a sensor called a charge-coupled device (CCD). The recorded image is then stored on the memory available to the camera and can be viewed on a screen. This file can be uploaded to a computer to be stored for the future. It can also be shared via email or social networking sites to show to friends and family.

The larger the number of pixels the CCD is capable of, the higher the quality of the image that can be taken. The quality of a digital camera is measured in pixels. If an image was zoomed in enough we would be able to see lots of very little squares of colour. These are the 'picture elements' (called 'pixels') and they are what an image is made of. In a poor-quality image it is quite easy to see these pixels when the image is enlarged. A camera on a mobile phone is normally about 3 or 4 megapixels (1 megapixel is 1 million pixels) whereas a professional camera could be 28 megapixels.

Table 5.06

Advantages of digital cameras	Disadvantages of digital cameras
An image taken with a digital camera can be immediately seen on a screen. Therefore the user can decide if they want to take another image instantly if they think that one is not good enough	If a digital camera only has a very small number of pixels, the quality of the image it can take may be lower than that of a camera that uses film
A backup copy can be made of any digital images taken. If the original copy of the images is then lost, the user still has a copy of them in the backup	When an image is taken with a digital camera you can immediately see it. It can also be immediately shared. Sharing the image could be accidental if they user didn't mean to do so. A user may accidental share images that they did not want to share
Images taken with a digital camera can easily be shared as they are an electronic copy. They can easily be attached to emails or uploaded to social networking sites	If a user has a lot of digital images taken with a digital camera they may require additional storage space. This could mean they need a larger SD card for the camera
An image taken with a digital camera can be easily edited as it is an electronic file	

5.06 Touch screen

A touch screen is an interactive device that combines a liquid crystal display (LCD) with touch-sensitive sensors. The sensors recognise simple touches, either by finger or by a stylus. The screen determines which part of the screen has been touched and, according to the application utilising it, translates the input into an action, such as simulating the clicking of an 'OK' button or selecting a drop-down menu. Additionally users can input text by touching keys on a virtual keyboard.

More complex touch screens can recognise gestures such as swipes or pivots. These gestures allow more complicated interactions, for example:

- switching between applications
- rotating an image
- increasing or decreasing the zoom on a document which is too large to fit on the screen
- drawing a picture by finger or stylus.

Touch screens are normally capacitive or resistive. A capacitive touch screen uses the natural electrical signals that we have in our bodies to detect when we are touching the screen. A touch screen that is capacitive will not be able to detect these signals through a glove. This is why when we have gloves on and try to use some touch-screen phones, the screen does not detect our touch. A resistive touch screen has multiple layers with space in between. When slight pressure is applied to the screen the layers touch and the device recognises that we are touching the screen.

Figure 5.15 Mobile phones often feature an interactive touch screen for input and output

Touch screens are considered to be a user-friendly device as the user can interact directly with whatever application or data is displayed. They are ideal for use with small devices such as smartphones, tablets, e-readers, PDAs and car satellite navigation systems because they eliminate the need for separate input and output devices. In fact without touch screen technology, such devices could not exist in their current form and would be much larger and more cumbersome to use. Touch screens are also used on much larger devices where a keyboard and mouse input system would be unsuitable, such as kiosk interactive tables in museums and exhibitions.

Due to their nature, touch screens can be quite imprecise. A finger touches the screen over a large area, making it very difficult to pinpoint a particular spot on the screen. Many touch screen interfaces use icons and large virtual buttons to overcome this issue. Alternatively some touch screens allow the use of a pen, or stylus, for precise control.

Figure 5.16 Tablets feature an interactive touch screen for input and output

Table 5.07

Advantages of a touch screen	Disadvantages of a touch screen
Touch screens are very simple to use	Touch screens can be quite imprecise, making it difficult to touch the required position accurately
Touch screens save space as they combine a screen and an input device in one	Inputs might not be possible if the screen is damaged

5.07 Interactive whiteboard

An interactive whiteboard acts as a virtual whiteboard. It works in a similar manner to a touch screen, except that the board is an input device only. It connects to a computer via a universal serial bus (USB) interface. (To learn more about USB, see Chapter 2.)

The computer's visual display is projected onto the board. The board is then calibrated (adjusted) to make sure the sensors it contains line up with the displayed image. The user touches the board either with a special pen or their finger. Sensors determine which part of the board has been touched and translates the touch into an action, for example selecting a menu option or clicking an 'OK' button. The input acts like a mouse pointer.

Interactive whiteboards come with their own special software that means they can be used like a real whiteboard, for example we can handwrite on it or draw diagrams. The

software also allows actions to be carried out such as moving of objects around the screen. Additionally, the software allows:

- handwriting recognition: The user can handwrite text onto the board that is translated into digital text.
- PC control: Applications can be run and controlled via the board's input.
- text input: A virtual keyboard can be displayed on the whiteboard and text input this way can be entered directly into a document or web browser.

Interactive whiteboards can be used in many different situations such as:

- education, at schools, colleges and universities: Their ease of use means that they are suitable for users of all ages and capabilities.
- sport: Interactive whiteboards are used in team planning and strategy sessions to help put across and discuss tactics.
- business: Interactive whiteboards are often used in meetings for discussion and for staff training.

Figure 5.17 Interactive whiteboards can be used in education

Figure 5.18 Interactive whiteboards can be used in business

Table 5.08

Advantages of an interactive whiteboard	Disadvantages of an interactive whiteboard
Interactive whiteboards are quite versatile – they be can written on, drawn on, display images and text	Interactive whiteboards must be accurately calibrated before use otherwise a user may touch the board in one place and the touch isn't registered
Interactive whiteboards offer a large screen that is excellent for use in a classroom or business environment	Interactive whiteboards can be quite imprecise, which can make it difficult to do any work that requires more complex detail

5.08 Microphone

A microphone is an analogue input device that records sound. Since computers operate digitally, the analogue sound wave must be converted into digital format before the computer can process it. The operation is performed using an **analogue-to-digital convertor (ADC)**. To learn more about analogue and digital data see Chapter 1.

KEY TERM

Analogue-to-digital convertor (ADC) – a device that converts analogue data into digital data.

Once in a digital format, the computer can save the sound in a file for later use. It can also transmit it to another computer. An example of this would be video conferencing, where a microphone is used to record and transmit speech from one user to another over the internet.

Additionally, the input from a microphone can be used for voice recognition:

- Speech-to-text software allows the user to speak words which the computer records and converts to text in a document. This system is ideal for users who have difficulty typing or for disabled users who have limited or no use of their hands.
- In-game speech allows video game players to communicate with each other when playing over the internet. The microphone is usually built into the player's headset.
- Speech input is now becoming used to control video game consoles and smart televisions. The speech instructs the console or television what application to run or what channel to switch to.

Figure 5.19 A microphone records analogue sound

Figure 5.20 Speech recognition systems are becoming more popular in the home such as in an Xbox 360 Kinect

One disadvantage of using microphones for speech recognition is that the sound might not be recorded clearly or be understood correctly. Users have individual speech patterns and

accents, not all of which are easy to understand for a computer. This can lead to incorrect input or no action occurring as the computer will not know what to do. To overcome this issue, speech recognition software allows users to train the computer to recognise their speech.

Table 5.09

Advantages of using a microphone	Disadvantages using a microphone
Microphones allow the use of speech recognition systems	Sound might not be accurately recorded
Disabled users with hand and finger impairment can use a microphone to input commands to a computer	Speech recognition systems have to be trained before they can be used properly

Summary

- An input device is a hardware device that allows data to be input into a computer system.
- Keyboards are one of the main and most common methods of entering data into a computer. A concept keyboard is a specialist keyboard with limited, specialised functions.
- A mouse is an input device that is used to navigate to a point on a screen. There are different types of mouse such as a trackball and a foot mouse
- 2D scanners scan a physical document by shining light into the surface of the document.
- 3D scanners produce a 3D model, rather than a 2D image, using a laser or a light source (or sometimes X-rays).
- Biometric devices use scanners to identify people.
- Barcodes are codes represented by black and white vertical bars. A barcode reader scans a barcode and translates it into a series of numbers.
- QR codes are made up of black and white squares. QR codes can link to many things such as a website, a video or a social networking profile. QR codes are scanned and read using a QR code reader.
- A digital camera records and encodes digital images and videos and stores them.
- A touch screen is an interactive device that combines an LCD visual display with touch-sensitive sensors. The sensors recognise simple touches.
- An interactive whiteboard is a virtual whiteboard that works in a similar manner to a touch screen. Interactive whiteboards are widely used in education, business and sport.
- A microphone is an analogue input device that records sound.

Exam-style questions

1 Identify two input devices that could be present in a mobile phone. (2 marks)

2 Explain what is meant by an input device. (1 mark)

3 Input devices can be either automatic or manual. Explain the difference between the two types. Give examples in your answer. (2 marks)

4 Explain how a business could make use of QR codes. (2 marks)

5 Explain how a touch screen device recognises that the screen is being touched. (4 marks)

6 Explain why, when using a microphone, an analogue-to-digital converter is also needed when inputting data. (3 marks)

7 Describe two benefits of using a digital camera over a film camera. (4 marks)

8 Describe how an interactive whiteboard could be used to help train staff in a company. (2 marks)

9 Describe how a barcode works and what data they usually store. (4 marks)

10 Explain how a 3D scanner works. Give an example in your answer. (3 marks)