

Solutions

Chapter 1: Understanding digital systems

Activity: Smart phone sensors, pages 3–4

Table 1.1

Sensor	What does it measure?	Use (e.g. by an app?)	Explanation of operation
Proximity sensor	Distance	Screen turns off when phone call is received and phone is near face	Emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal.
Ambient light sensor	Light level	Modifies brightness of screen between day/night	Photo diode used to convert light level to current.
Front camera	Analog images	Video chat	Tiny picture elements detect light intensity and colour (using filters) falling on them and convert these to electrical signals and to a final digital file.
Rear camera	Analog images	Take videos or photos	As above
Accelerometer	Acceleration	Tells if phone is portrait/landscape. Detects shake, tilt, etc.	Most smartphone accelerometers use the piezoelectric effect – they contain microscopic crystal structures that are stressed by accelerative forces, which causes a voltage to be generated.
Gyroscope	Orientation	More accurate 3D axis orientation than accelerometer	The motion of a pair of sensing arms produces a voltage difference from which angular velocity is sensed. The angular velocity is converted to, and output as, an electrical signal. Excellent video at https://youtu.be/zwe6LEYF0j8
Compass	Direction	Compass directions	Smartphones have a magnetometer, which measures the Earth's magnetic field. This data is combined with the accelerator, which provides the phone's position in space. The compass can display compass directions no matter which orientation the phone is in.

Sensor	What does it measure?	Use (e.g. by an app?)	Explanation of operation
Barometer	Atmospheric pressure	Height above sea level is used to fine-adjust GPS readings from satellites	A small cantilever over the opening of a chamber acts as a pressure sensitive valve, slowing the flow of air between the chamber and the outside world. Whenever there is a pressure difference between the two, the cantilever bends, and the rate of flow between them increases. Once the pressure is equalised, the cantilever relaxes. By making the cantilever out of a piezoresistive material, the electrical resistance of the cantilever changes as it bends, providing a direct measure of the bending.
Near-field communication (NFC)	EMF fields	Making payments in shops	Electromagnetic field induces current in coil of wire
Touch fingerprint scanner	Sensor	Locking and unlocking phone	A small current is passed through finger to create a 'fingerprint map' of user's skin ridges.
Temperature	Battery temperature	Turns off phone when it overheats (as if left in a locked hot car)	A thermistor inside the battery checks battery temperature.

Activity: How does a computer monitor work?, pages 4–5

- 1 D: Light from a fluorescent panel spreads in waves that vibrate in all directions.
- 2 A: A polarising filter only lets through the light waves that are vibrating horizontally.
- 3 F: The light waves then pass through the liquid crystal layer. Each crystal cell is charged by varying amounts to twist the vibration of the wave.
- 4 C: One of three coloured filters then colours the light red, green or blue.
- 5 B: A second polarising filter only lets through light vibrating in a vertical plane.
- 6 E: The mixture of colours on the front panel combine. In this example, full red, half green and no blue will result in a pixel appearing pale brown.

Activity: How does a laser printer work?, page 5

Signals from the computer control a laser beam. The laser beam is caused to sweep horizontally by being bounced off a spinning hexagonal mirror. The laser beam turns on or off as it sweeps across a horizontal line producing a pattern of charged spots on the surface of a rotating light-sensitive drum. The drum dips in powdered toner, which is attracted to the parts that have a charge. An oppositely charged piece of paper is pressed to the drum and the toner is transferred to the paper. This is then fused to the paper using heated rollers.

Web probe: Ports, page 6

Table 1.2

Port	What is it used for?
USB	The most widely used port; can be used to connect many types of devices
HDMI	Popular in entertainment equipment such as high-definition LCD or plasma TVs, and for connection to smartboards or display screens
VGA	Analog connection to a monitor, data projector or LCD TV
Memory card reader	Accepts most digital camera cards, including secure digital (SD) cards
LAN/Ethernet	Connection to a wired computer network or high-speed broadband
DVI	Digital connection to a monitor or HD TV
USB-C/Thunderbolt 3	Multiple ports of only this type on Apple laptops used for power, USB, HDMI, DVI, VGA, Ethernet

Web probe: Storage, page 8

Table 1.4

Storage method	Advantages	Disadvantages	Typical capacity in GB	When would you use it?
DVD	Cheapest way to mass produce storage for larger files	Can be damaged easily. Require DVD reader, now not in every device.	4.7 GB	Share a large file with friend
Flash (USB) stick	Small, cheap and easily transportable	Lost easily. Lower storage capacity. Limited life.	8 GB	Swap small files quickly without connecting over network
HDD	High capacity at lower cost. Detachable external devices readily available	Mechanical parts can fail. Damaged by dropping. Damaged by stronger magnetic radiation.	Approx. 1 TB	Secondary storage commonly included in computers
SSD	No moving parts, fast startup and access, not easily damaged	More expensive	500 GB	Secondary storage commonly included in computers
The cloud	No cables or peripheral storage hardware required. Collaboration in real time	Must have internet connection	Unlimited	Collaborative projects. Storage of personal files accessed by multiple devices

Knowledge probe: Sizing it up, page 9

Table 1.5

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Size	How many bytes?	Typical example
1 bit	one-eighth of a byte	Answer to a yes/no question
1 byte	1 byte	A single letter of the alphabet
90 bytes	90 bytes	A line of text from a book
0.5 KB	500 bytes	Typical sector of a hard disk
4 KB	4000 bytes	One page of text from a novel
1 MB	1 000 000 bytes	1024×1024 pixel bitmap image using 256 colours
3 MB	3 000 000 bytes	A three-minute song
650–900 MB	650 000 000–900 000 000 bytes	A CD-ROM
1 GB	1 000 000 000 bytes	One hour of an SD streamed movie
8 GB	8 000 000 000 bytes	Size of a regular flash drive
4 TB	4 000 000 000 000 bytes	Size of a \$150 hard disk
1.3 ZB	1 300 000 000 000 000 000 000 bytes	Size of the entire Internet in 2016

- 2** A ZB stands for a zettabyte. It is 10^{21} bytes or 1 000 000 000 000 000 000 000 bytes or strictly speaking 1 180 591 620 717 411 303 424 bytes as memory is measured to nearest power of 2.

Web probe: What is a floppy disk?, page 10

There were three generations of floppy disks: 8-inch (500 KB), 5¼-inch (720 KB), and 3½-inch (1.44 MB) floppy disks. The first two were bendable, hence the name. A magnetically coated disc spins between two Mylar surfaces. A magnetic head records and reads from the slot.

Review, pages 14–15

Identify

- 1 Input, output, processing storage and control.
- 2 A collection of hardware and software components. A computer is part of a digital system. Digital systems transform data and can be connected to form networks.
- 3 Digital systems combined with data, processes and people to collect, organise and communicate information.
- 4 Data is information that has been given meaning by people and can be represented in many forms. Information is data given context and organisation. Data in its raw form is represented using numerical codes.

Analyse

- 5 A HDD is a hard disk drive. It typically has high capacity at lower cost than a SSD (solid state device). It has mechanical parts that may fail through physical damage or magnetic radiation.
- 6 RAM is random access memory, which is volatile. This means its contents are lost when power is switched off. It is used to store data temporarily necessary for processing. ROM is read only memory and is non volatile and is retained when power is switched off. It is used to store data needed when a computer is starting up.
- 7 Kilo, mega, giga, tera and peta.
- 8 Embedded hardware systems are specialised computer systems combining hardware and software in one system. They typically include a dedicated application performing a specific function. Examples include washing machines, microwave ovens, dishwashers and car engine control systems.

Investigate

- 9 Students' responses will vary.