# Answers to Computer Systems Workbook

## 1 Data representation

1 a 165 = 1 0 1 0 0 1 0 1

b 165 = A 5

2 a 0 1 1 1 0 1 1 0 = 118

b 5 F = 95

c 1 0 1 0 1 1 0 0 0 1 0 0 = A C 4

d 3 E D = (0 0) 1 1 1 1 1 0 1 1 0 1

3 a 800 × 16 = 12 800 MiB

b 12 800/1024 = 12.5 GiB

4 a i 65 = 0 1 0 0 0 0 0 1

ii 97 = 0 1 1 0 0 0 0 1

b i V = 86

ii v = 118

c i 86 = 0 1 0 1 0 1 1 0

ii 118 = 0 1 1 1 0 1 1 0

d Lower-case letters have an ASCII code value which is + 32 when compared to the equivalent upper-case letter, therefore to convert from an upper-case value, simply place a '1' in the column with value 32.

M = 77 = 0 1 0 0 1 1 0 1 and m = 77 + 32 = 109 = 0 1 1 …

5 a

| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
|---|---|---|---|---|---|---|---|

b i

| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
|---|---|---|---|---|---|---|---|

ii 132

c i R = 27 = 0 0 0 1 1 0 1 1

r = 108 = 0 1 1 0 1 1 0 0

ii M = 22 = 0 0 0 1 0 1 1 0

m = 88 = 0 1 0 1 1 0 0 0

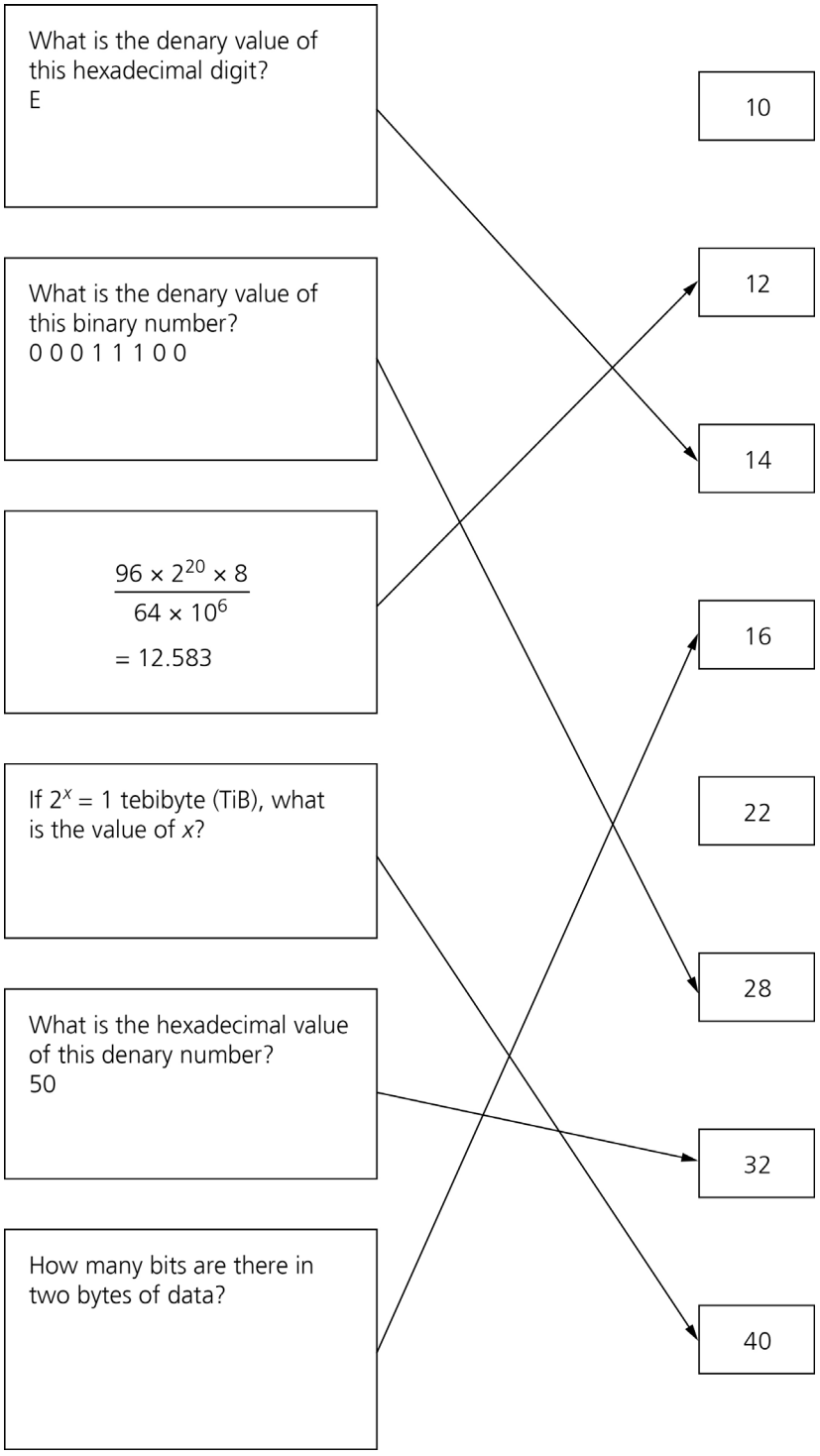
**6** **a** 44801 = A F 0 1

**b** 1 0 1 0  1 1 1 1  0 0 0 0  0 0 0 1

**7** Three from:

- memory dumps
- error codes
- MAC addresses
- IP addresses
- HTML colour codes

**8**



**9 a i**

| Number | X | D | OUTPUT |
|---|---|---|---|
| 220 | 220 | 128 | |
| | 92 | | 1 |
| | | 64 | |
| | 28 | | 1 |
| | | 32 | |
| | −4 | | 0 |
| | 28 | | |
| | | 16 | |
| | 12 | | 1 |
| | | 8 | |
| | 4 | | 1 |
| | | 4 | |
| | 0 | | 1 |
| | | 2 | |
| | −2 | | 0 |
| | 0 | | |
| | | 1 | |
| | −1 | | 0 |
| | 0 | | |
| | | 0 | end |

ii

| Number | X | D | OUTPUT |
|---|---|---|---|
| 73 | 73 | 128 | |
| | −55 | | 0 |
| | 73 | | |
| | | 64 | |
| | 9 | | 1 |
| | | 32 | |
| | −23 | | 0 |
| | 9 | | |
| | | 16 | |
| | −7 | | 0 |
| | 9 | | |
| | | 8 | |
| | 1 | | 1 |
| | | 4 | |
| | −3 | | 0 |
| | 1 | | |
| | | 2 | |
| | −1 | | 0 |
| | 1 | | |
| | | 1 | |
| | 0 | | 1 |
| | | 0 | end |

b The flowchart is converting denary (base 10) numbers into 8-bit binary (base 2) numbers.

10 a i 94

ii 61

b i 1 0 0 1 1 0 1 1

ii 155

This is equal to 94 + 61 in denary.

**11 a** largest number = 1 1 1 1 1 1 1 1 = 255

**b i** 0 1 1 1 0 1 1 1 + 1 0 0 1 1 1 0 1 = 1 0 0 0 1 0 1 0 0

**ii** A ninth bit is generated therefore overflow error has occurred (i.e. the result exceeded the largest possible number which can be stored using 8 bits).

**12 a** 32 + 16 + 8 + 4 = 60

**b i** 0 0 0 1 1 1 1 0

**ii** denary value = 30

**iii** 0 0 0 0 0 1 1 1 – result is 7 which is incorrect (30 ÷ 4 = 7.5); 1-bit has been lost

**c i** 1 1 1 1 0 0 0 0

**ii** Value is 240 which is equivalent to $60 \times 2^2$ – this is because each logical shift left multiplies the original binary number by 2. Two shifts left multiplies by $2^2 = 4$.

**13 a** 37 = 0 0 1 0 0 1 0 1 and 19 = 0 0 0 1 0 0 1 1

**b** 0 0 1 1 1 0 0 0

**c** 1 1 1 0 0 0 0 0; denary value of (b) is 56; after logical shift, value is $56 \times 2^2 = 224$

**d** 0 0 0 0 0 0 1 1 – value after shift is 3 which is incorrect since $56 \div 2^4 = 3.5$; a 1-bit has been lost

**14 a** −128

**b i** Most negative is 1 0 0 0 0 0 0 0 = −128

**ii** Most positive is 0 1 1 1 1 1 1 1 = +127

**c i** 47 = 0 0 1 0 1 1 1 1

**ii** −59 = 1 1 0 0 0 1 0 1

**d i** 1 1 0 0 1 1 1 0 = −50

**ii** 1 1 1 1 1 1 1 0 = −2

**e i** 45 = 0 0 1 0 1 1 0 1

**ii** −45 = 1 1 0 1 0 0 1 1

**iii** 1 0 0 0 0 0 0 0 0 – in two's complement the final carry to the 9th bit does **not** signify overflow. We ignore this bit and consider the other 8 bits, which do give the correct answer of zero.

**15 a** (4096 × 2048 × 16)/(8 × 1024 × 1024) = 16 MiB

4096 × 2048

× 16 and ÷ 8

divide by 1024 × 1024

16 MiB

**b** size of sample = (number of samples per sec) × (number of bits per sample) × (length of sample size in secs) = (40 960 × 16 × 1024) bits

multiply by 2 for stereo recording and divide by 8 to get number of bytes

divide by (1024 × 1024)

to give 160 MiB

(40 960 × 16 × 2 × 1024)/(8 × 1024 × 1024) = 160 MiB

**16 a** It saves storage space on the HDD/SSD.

It is faster to upload/download files to/from the internet.

It reduces the file size which allows the file to be emailed.

**b** Lossless – all data from the original file can be reconstructed when the file is uncompressed again.

Lossy – the compression algorithm eliminates unnecessary data from the original file; the original file cannot be reconstructed once it has been compressed.

**c i** mpeg-3, mpeg-4 or jpeg

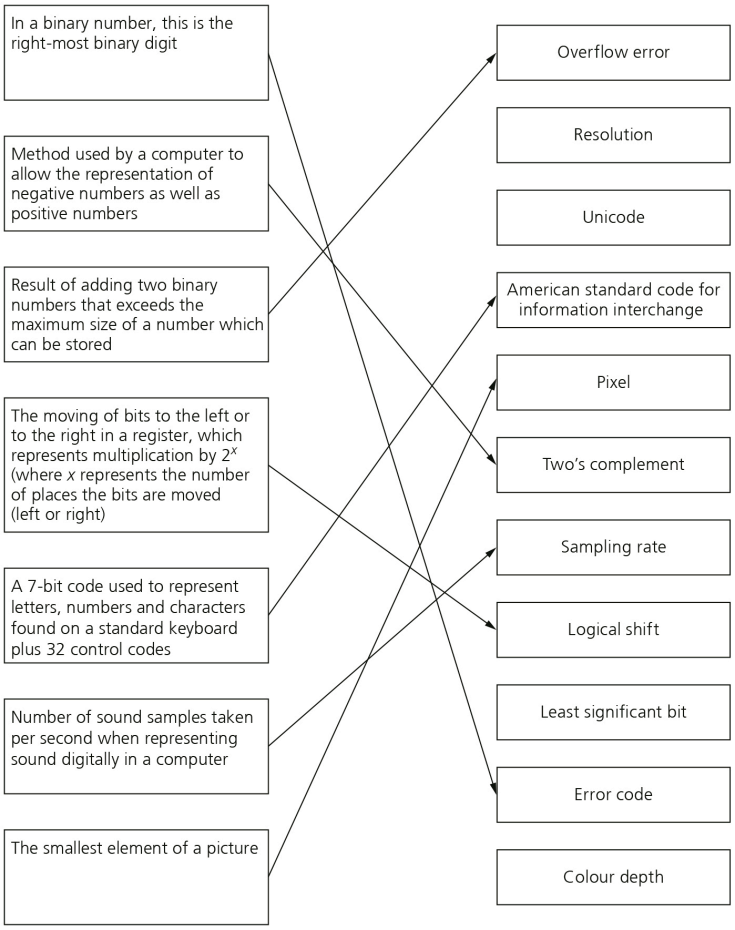
**ii** RLE (run-length encoding)

**17 a** colour depth – the number of bits used to represent each colour

**b** image resolution – the number of pixels that make up an image, for example, 4096 × 3192

**18**
- Standard ASCII code consists of 7-bit codes.
- It represents letters, numbers and characters found on a standard keyboard + 32 control characters.
- Extended ASCII code uses 8-bit codes, which allows for non-English characters.
- Unicode can be used to represent all languages of the world.
- Unicode overlaps with ASCII code since the first 128 characters are the same, but Unicode can support several thousand different characters.
- ASCII code uses one byte to represent a character, whereas Unicode will support up to four bytes per character.

**19**



**20 a** B

**b** D

**c** A

**d** D

**e** B

**21 a** It is a form of lossless file compression:

- It reduces the size of a string of adjacent, identical data.
- A repeated string is encoded into two values:
  - The first value represents the number of identical data items.
  - The second value represents the code of the data item.
- RLE is only effective where there is a long run of repeated units.

**b i** 3W 2D 5W 4D 3W 1D 1W 2D 1W 1D 1W 16D 1W 1D 1W 2D 1W 1D 3W 4D 5W 2D 3W

**ii** 8 × 8 grid requires 64 bytes of storage

46 bytes are used in the RLE code

reduction = 64 − 46 = 18 bytes

**22 a i** the number of bits used to represent sound amplitude

**ii** the number of sound samples taken per second

**b i** 4 bits (15 = 1111)

**ii** 10 Hz (i.e. 10 samples per second)

**iii** point 9: (14) = 1 1 1 0

point 18: (11) = 1 0 1 1

**c** Benefits:

- larger dynamic range
- better/more faithful sound quality
- less sound distortion

Drawbacks:

- produces larger files
- takes longer to transmit/download music files
- requires greater processing power

**23** For example:


986 → 3 D A

- Keep dividing by 16 until the value 0 is reached.
- Keep track of remainders following each division.
- The hexadecimal number is obtained from the reminders reading from bottom to top.
- It is necessary to convert remainders that are greater than 9 into the hex characters A, B, C, D, E or F.

**24** **a** binary digit

**b**
- (computer) circuits are made up of switches/transistors …
- … which can be ON (1) or OFF (0)

**c**
- hex is a more human-friendly representation of binary values …
- … since it uses only 2 digits to represent an 8-bit binary number (greater information density)
- it is easy to interconvert between hex and binary …
- … which makes it easier when writing software or diagnosing errors in software

# 2 Data transmission

**1** **a** A data packet is when message/data is split up into smaller groups of bytes:
- for transmission over a network
- containing a header, payload and a trailer

**b** In any order:
- IP address of the sender
- IP address of the recipient
- the sequence number of the data packet
- the size of the packet (in bytes)

**c**
- The payload contains the actual data being sent in the packet.
- The trailer is a way of identifying the end of a packet and it also contains an error-checking method, such as a cyclic redundancy check (CRC).

**d i**
- The 500 KiB file is split up into a number of packets.
- Each packet will follow its own path from 'A' to 'B'.
- Routers (R1 to R10) will determine the path of each data packet.
- The routing selection depends on the number of packets (at each router).
- The shortest path available is always selected.

**ii**
- Data packets frequently reach the destination in a different order to the one in which they are sent …
- … which means the data packets need to be re-assembled into the correct order.

**2 a** Three from:
- There is no need to tie up a single communications line.
- It is possible to overcome failed, busy or faulty lines by re-routing packets.
- It is relatively easy to expand package usage.
- A high data transmission rate is possible.

**b** In any order:
- Packets can be lost and need to be re-sent.
- The method doesn't work well with real-time streaming.
- There is a delay at the destination while waiting for all of the packets to arrive and then to reassemble them in the correct order.

**c** The network would grind to a halt as the number of lost packets mount up, 'clogging up' the system.

**3 a**

| **Description of transmission taking place** | **Simplex (✓)** | **Half-duplex (✓)** | **Full-duplex (✓)** | **Serial (✓)** | **Parallel (✓)** |
|---|---|---|---|---|---|
| Data sent one bit at a time down a single wire in one direction only | ✓ | | | ✓ | |
| Data sent 16 bits at a time down 16 wires in both directions, but not at the same time | | ✓ | | | ✓ |
| Data sent 16 bits at a time down 16 wires in both directions simultaneously | | | ✓ | | ✓ |
| Data sent 8 bits at a time down 8 wires in one direction only | ✓ | | | | ✓ |
| Data sent one bit at a time down a single wire in both directions simultaneously | | | ✓ | ✓ | |
| Data sent one bit at a time down a single wire in both directions, but not at the same time | | ✓ | | ✓ | |

**b**

| Statements | Serial (✓) | Parallel (✓) |
|---|---|---|
| Transmission method used by the memory bus inside a computer | | ✓ |
| Data can be skewed (out of synch) when travelling over long distances | | ✓ |
| Least expensive of the two types due to fewer hardware requirements | ✓ | |
| Most appropriate where faster transmission rate is essential | | ✓ |
| Suffers from less risk of external interference | ✓ | |

**4 a**

- The computer automatically detects a device being connected.
- The device is automatically recognised and appropriate device driver software is loaded up.
- If a new device is connected for the first time, the computer will look for a device driver that matches the device or the user is prompted to download the device driver from the internet.

**b**

| Statements | True (✓) | False (✓) |
|---|---|---|
| USBs use a protocol that allows for error-free data transmission between device and computer | ✓ | |
| USBs can support any cable length between device and computer | | ✓ |
| USBs use serial data transfer | ✓ | |
| USB connections can transfer data using half-duplex or full-duplex | ✓ | |
| It is difficult to add more USB ports to a computer using USB hubs | | ✓ |
| USB data transfer rates are much faster than, for example, Ethernet connections | | ✓ |
| There is no need for devices to have a power source because USB cable supplies 5V of power | ✓ | |

**5** **a** pass, fail, fail

**b** to check for errors following data transmission

**c** **i** bit number = 4, byte number = 6

**ii** bit 4 has odd parity (five 1-bits), byte 6 has odd parity (five 1-bits)

**iii** corrected byte is: 0 1 1 1 1 1 0 1

**iv** if even parity retained (for example, if two bits have changed)

**v**
- **checksum**: a method which calculates a check sum from the block of data being sent; the value is sent at the end of the block of data
- **echo check**: a method where the data is sent back to the sender which then checks that it matches the data originally sent
- **Automatic Repeat Request (ARQ):** a method that uses time-out and acknowledgement to automatically request the re-sending of data

**6** **a**
- A checksum is calculated from a block of data.
- The calculation is done using an agreed algorithm.
- The checksum is transmitted with the block of data.
- At the receiving end, the checksum is recalculated by the computer using the block of data just sent (using the same agreed algorithm).
- The recalculated checksum is compared to the checksum sent with the block of data.
- If both checksums are the same, then no transmission errors have occurred; otherwise a request to re-send the data block is made.

**b**
- A copy of the data is sent back to the sender.
- The returned data is compared to the original data sent by the sending computer.
- If there are no differences, then the data has been sent without error.
- If the two sets of data have differences then an error has occurred at some stage during the data transmission.

**c**
- They use an acknowledgement and time-outs.
- When a receiving device detects an error following data transmission, it asks for the data packet to be re-sent.
- If no errors are detected, a positive acknowledgement is sent to the sender.
- The sending device will re-send the data packet if:
  - a request to re-send data has been received, OR
  - a time-out has occurred
- The whole process is continuous until the data packet received is correct or until the time-out is reached.

**7** **a** In any order:
- an incorrect digit entered, for example, 5327 instead of 5307
- a transposition error occurred, for example, 5037 instead of 5307
- omitted or extra digits, for example, 537 or 53107 instead of 5307
- phonetic errors, such as 13 (thirteen) instead of 30 (thirty)

**b i** 9 **7** 8 **1** 4 **7** 1 **8** 6 **8** 6 **7**

9 + 8 + 4 + 1 + 6 + 6 = 34

3 × (**7 + 1 + 7 + 8 + 8 + 7**) = 3 × 38 = 114

34 + 114 = 148

148/10 = 14 remainder 8

10 – 8 = 2; the check digit

**ii** 9 **7** 8 **1** 4 **7** 1 **8** 0 **7** 2 **1** 8

9 + 8 + 4 + 1 + 0 + 2 + 8 = 32

3 × (**7 + 1 + 7 + 8 + 7 + 1**) = 3 × 31 = 93

32 + 93 = 125

125/10 = 12 remainder 5

Therefore, the check digit is incorrect – an input error has occurred.

**8 a** E

**b** B

**c** B

**d** E

**e** A

**f** E

**g** A

**h** B

**i** D

**j** A

**9 a** A data packet header doesn't contain MAC addresses. It contains the IP addresses of the sender and recipient.

**b** Half-duplex refers to data sent in both directions, but not at the same time. The use of four bits sent along four channels refers to parallel transmission.

**c** Although USB has become an industry standard, this has nothing to do with the orientation of connectors. USB connectors can only be fitted in one way.

**d** Odd parity is to do with the number of 1-bits and nothing to do with the denary value of the number. Odd parity means a byte contains an odd number of 1-bits.

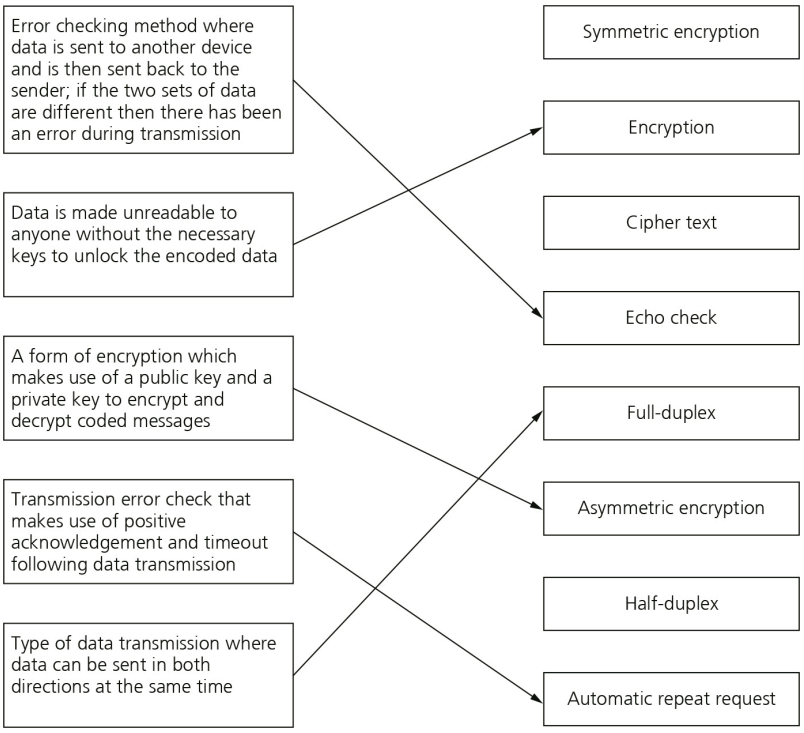
**e** Even parity is measured by checking if an even number of 1-bits are sent. A number such as 0 1 1 0 1 1 0 0 1 has four 0-bits but has five 1-bits and is therefore not showing even parity.

**f** Check digits are used to check if data has been entered correctly. They are not used to check for transmission errors.

**g** A checksum is calculated from bytes in the data block and not from the 1-bits in a single byte.

**h** Asymmetric encryption uses two separate keys – a public key and a private key.

**10**




**11**

- asymmetric encryption
- public
- private
- document
- algorithm
- matching pairs
- mathematically
- public key
- public key
- encrypted
- matching private
- document
- decrypt

# 3 Hardware

**1**

- step 1: 4
- step 2: 1
- step 3: 2
- step 4: given in flowchart
- step 5: 5
- step 6: 3

Please note: step 5 (increment PC) could also be shown in steps 2 or 3 in the flowchart.

**2 a** address bus, data bus and control bus

**b i** MAR: 1111 1110 MDR: 1010 0111

**ii** MAR: 1000 0100 MDR: 1100 1101

**iii**

| Address | Contents |
|---|---|
| 1000 0000 | 0111 1100 |
| 1000 0001 | 1000 0011 |
| 1000 0010 | 1111 1101 |
| 1000 0011 | 0111 1110 |
| 1000 0100 | 1100 1101 |
| ↓ | ↓ |
| 1111 1100 | **0011 1100** |
| 1111 1101 | 0110 0011 |
| 1111 1110 | 1010 0111 |
| 1111 1111 | 1111 0011 |

The greyed cell in the diagram in the Workbook should contain 00111100.

**c** CIR: current instruction register – stores the current instructions being decoded and executed

MAR: memory address register – stores the address of the memory location currently being read from/written to

MDR: memory data register – stores data which has just been read from memory/data and is about to be written to memory

PC: program counter – stores the address where the next instruction to be read can be found

**3 a i** Clock speeds are measured in GHz, which is the vibrational frequency of the clock which sends out pulses along the control bus to synchronise operations.

**ii** A temporary memory location using static RAM to hold data/instructions that are frequently used by the processor; a larger cache memory increases processor performance.

**b** Increasing clock speed can improve performance; however, it can lead to overclocking, which can cause operations to be unsynchronised, which can cause serious overheating of the CPU. Use of more cores can improve processor performance (for example, dual core and quad core). However, doubling the number of cores doesn't necessarily double the performance because the CPU needs to communicate with each core, reducing the overall performance.

**4 a i** a combination of hardware and software designed to carry out a specific set of instructions

**ii** In any order:

- small in size and therefore easy to fit into devices
- relatively cheap to manufacture
- dedicated to a single task which allows for a simple interface and OS
- consumes very little power

iii Three from:

- set top boxes – to allow the recording and playback of TV programmes
- security systems – use sensors to check for intruders and send a warning signal if an intruder is detected
- lighting systems – automatic control of lighting using light sensors, for example, time of day, whether the room is occupied, light intensity changes, etc.
- vending machines – to automatically supply customers with an item from a machine; they use a keypad, sensors and a number of actuators to supply the item
- motor vehicles – they control/monitor the functions of many of the components in a car
- washing machines – automatically control the wash cycle

**b** i Gaming devices involve sensors to give a degree of realism to games:

- accelerometers (these measure acceleration and deceleration and therefore measure and respond to tilting the gaming device forward/backward and side to side)
- proximity sensors (used in smart touch pads; here electrodes are embedded in touch pads which can detect hand/finger position thus increasing user movements and user awareness)
- embedded accelerometers and proximity sensors (together with a microcontroller) in games consoles allow increased human interaction with the game – this allows players to take actions which simulate real events happening, giving a more immersive games experience.

ii
- automatic updates are sent via a cellular network
- automatic updates are received by plugging a device into a computer or via a WiFi/Bluetooth connection

**5 a** A: 0 1 1 1 1 0 1

B: 0 1 0 1 1 1 1

C: 0 1 1 0 0 0 1

**b** Inputs:

- scanner – to read the barcode
- keypad – to enter the barcode number if the barcode fails to scan
- card reader – to allow payments

Outputs:

- monitor – to show an item's description and/or price
- loudspeaker – to give 'beeping' sounds to indicate that the item has been read correctly or that there was an error in reading the barcode
- printer – to produce an itemised bill and customised vouchers

**c** Manager, two from:

- easier to change the prices on stock
- more up-to-date sales information can be automatically generated
- no need to price each item individually
- automatic stock control
- customer's buying habits can be easily checked (by linking purchases to a loyalty card)

Customer, two from:

- faster checkouts
- fewer errors in the bills
- itemised billing
- cost savings passed on to customers
- less chance of food being out of date

**6 a**

- adjust the shutter speed
- focus the image automatically
- operate the flash automatically
- adjust the aperture size
- adjust the size of the image
- 'red eye'

**b** Note: don't accept answers such as 'taking a photograph of a scene'.

Two from:

- reading QR codes using a smart phone/tablet
- robots and other devices where information about the surroundings is needed (e.g. autonomous vehicles or reconnaissance drones)
- diagnosis of patients (e.g. dental work for easier detection of problems)
- security systems (e.g. use of infrared sensors to trigger a camera to take a photo or move the camera)
- video conferencing and other forms of conferencing
- producing virtual reality tours
- producing data for use in satellite navigation systems and online 'maps'
- augmented reality (e.g. when selling cosmetics, the camera in a device can be used to show how a person would look when using different cosmetics)

**7**

| Application | Most suitable input device |
|---|---|
| Entering text and numbers into a word processor or spreadsheet | Keyboard |
| Selecting an option or icon from an on-screen menu | Touch screen/pointing device |
| Input a user's voice into a computer as part of a voice recognition system | Microphone |
| Converting a hard copy document into an electronic form to be stored in a computer | (2D) scanner |
| Reading of a QR code using a smartphone or tablet | Camera |
| Keying in digits from a barcode which didn't scan correctly | Keypad |
| Read data directly from the surroundings, such as taking a temperature | Sensor |

**8**

| Touch screen technology | Advantages | Disadvantages |
|---|---|---|
| Capacitive | • better image clarity than other technologies<br>• very durable screens with good scratch resistance<br>• allows multi-touch facility | • surface capacitive screens only allow use of bare fingers or stylus<br>• sensitive to electromagnetic radiation |
| Infrared | • allows multi-touch facility<br>• good screen durability<br>• not affected by scratched/cracked screen | • can be sensitive to water/moisture on screen surface<br>• possible accidental activation<br>• sensitive to light interference |
| Resistive | • good resistance to dust and water<br>• can be used with fingers, stylus or gloved hand | • low touch sensitivity<br>• doesn't support multi-touch facility<br>• poor visibility in strong sunlight<br>• vulnerable to scratches on screen |

**9** **a** Three from:

- higher contrast ratios
- greater longevity
- quieter running
- no issues lining up images
- smaller and lighter than LCD projectors
- better suited to dusty and smoky atmospheres

**b** Two from:

- The image tends to suffer from 'shadowing' during moving images.
- They do not have grey components in the image.
- Colour definition is not as good as LCD projectors.

**10 a** inkjet printers:

advantages:

- don't produce ozone gas
- produce high-quality photo/vivid colour images
- small footprint
- don't need to warm up
- very low purchase price

disadvantages:

- have a small ink reservoir
- small paper trays
- not suitable for long print runs (ink cartridges can be used up quickly)
- can't use highlighter pens on printouts as ink smudges
- print heads are not very durable

laser printers:

advantages:

- have large paper trays for long print runs
- have large capacity toner cartridges
- very quiet printing
- cost per page is very low

disadvantages:

- produce ozone gas (an irritant) (Don't allow this point if given as an advantage of using an inkjet printer.)
- expensive to maintain (cartridges and other parts, such as the diffuser, are expensive)

**b i** laser printer

- large number of leaflets; therefore, need large amounts of paper and ink to do the print run

**ii** inkjet printer

- one off, therefore, speed not essential
- inkjet printers good at producing high definition photo-quality printouts

**iii** 3D printer

- items for sale need to be solid coins and feel like the real thing
- 3D printers can produce coins from layers of resin/plastic or metal powders resembling original coins

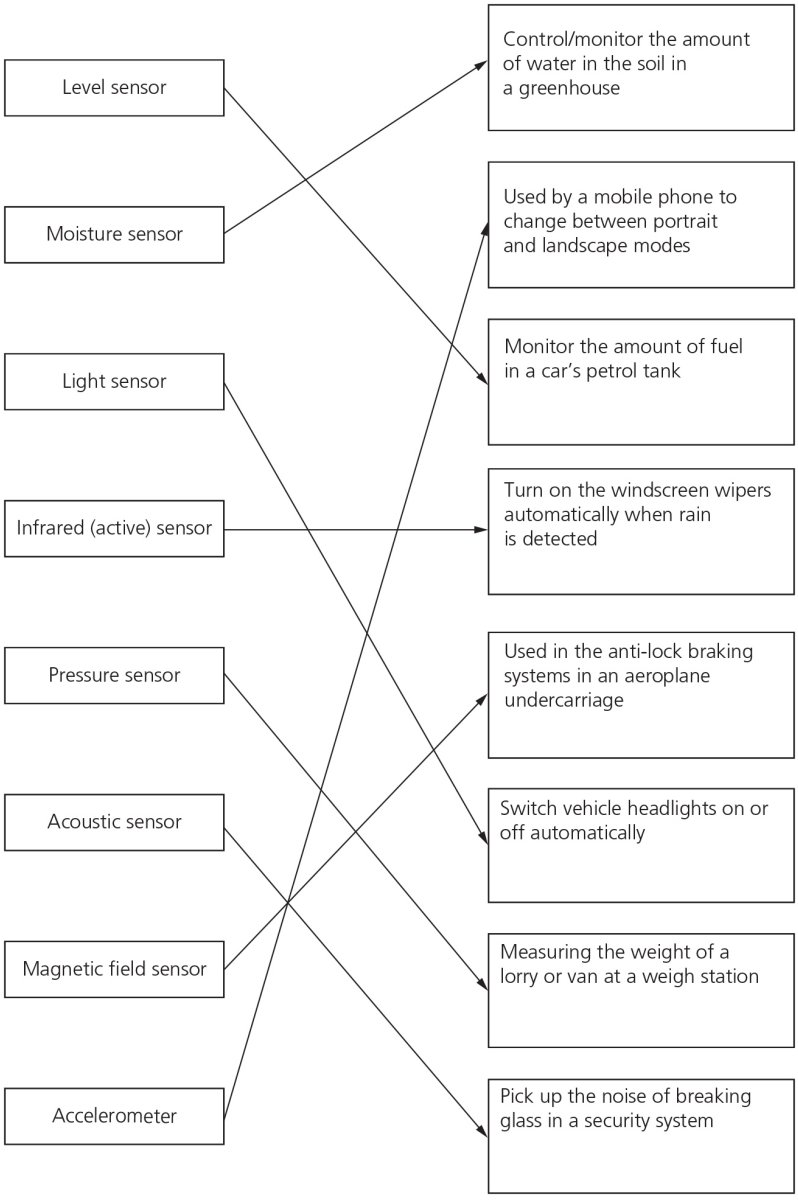
**11 a**

- The enthusiast makes a drawing of the part or finds a blueprint.
- The finalised drawing is imported into special software that prepares it in a format understood by the 3D printer.
- A solid object is built up layer by layer; the material used is a metallic powder in this case.
- The object is removed from the printer and is then prepared by removing any support material.

**b** Three from:

- prosthetic limbs
- facial construction and other reconstructive surgery
- making parts in the aerospace industry
- fashion and art
- prototypes, for example, in the design of a new games console

**12**



**13 a** infrared sensor (passive and/or active), acoustic sensor (microphone), pressure sensor

**b**
- The sensors continually send data to the microprocessor.
- Data is converted to digital form by an ADC.
- The microprocessor compares data to pre-set values.
- If an infrared (active) beam is broken, the microprocessor sends a signal to an actuator to operate a siren/flashing lights.
- If an infrared (passive) value > pre-set value, the microprocessor sends a signal to an actuator to operate a siren/flashing lights.
- If the microphone/acoustic sensor readings > pre-set value, the microprocessor sends a signal to an actuator to operate a siren/flashing lights.
- If a pressure sensor reading > pre-set value, the microprocessor sends a signal to an actuator to operate a siren/flashing lights.
- The process is continuous.

**14 a** primary:
- directly addressable by the CPU
- part of the CPU/motherboard
- contains RAM/ROM/cache

secondary:
- not directly addressable by CPU
- non-volatile devices
- often external to computer
- for example, HDD, SSD

**b**

| **Description** | **RAM (✓)** | **ROM (✓)** |
|---|---|---|
| Temporary memory device | ✓ | |
| Non-volatile memory | | ✓ |
| Data stored in this memory cannot be altered | | ✓ |
| Permanent memory device | | ✓ |
| Stores data and part of the operating system currently in use | ✓ | |
| Can be increased in size to improve the operational speed of a computer | ✓ | |

**c i**
- radio frequency to control the device
- software to carry out the basic functions of a device
- start-up procedures when the device is powered up

**ii**
- a user's own programs/routines to control the car
- part of the software needed to control the car's manoeuvres
- temporary new radio frequencies

**iii**
- to allow connection to the computer to get software updates
- to connect a small memory stick containing pre-programmed routines

**15**

| | Technology used | | |
|---|---|---|---|
| **Description** | **Magnetic** | **Optical** | **Solid state** |
| Makes use of floating gate and control gate technology | | | ✓ |
| Disk surfaces are made up of tracks and sectors; storage relies on certain properties of the iron oxide coating | ✓ | | |
| Devices using this technology have no moving parts | | | ✓ |
| Data is stored in 'pits' and 'lands' on a single spiral track running from the centre outwards | | ✓ | |
| Disks use the properties of laser radiation to allow read and write operations | | ✓ | |
| Data is stored by controlling the movement of electrons within NAND chips | | | ✓ |
| This technology is affected by strong magnetic and radio fields | ✓ | | |

**16**

| Statement | True (✓) | False (✓) |
|---|---|---|
| Devices using magnetic media have a very slow data transfer rate | | ✓ |
| HDD platters can be made from ceramic, glass or aluminium coated in iron oxide | ✓ | |
| HDD surfaces are split up into tracks and sectors | ✓ | |
| HDD use a more reliable technology than solid state devices, such as SSD | | ✓ |
| DVD-Rs are used to read and write data several times | | ✓ |
| DVD and Blu-ray disks can both use dual-layer technology | ✓ | |
| SSDs suffer from a high degree of latency | | ✓ |
| Solid-state devices, known as flash drives, use NAND chip technology | ✓ | |
| SSD data access time is approximately 100 times less than the data access time for HDD | ✓ | |
| Memory cards (such as the SD and XD cards used in cameras) are examples of magnetic media | | ✓ |

**17** How VM works:

- It utilises RAM and HDD/SSD.
- RAM is physical memory and swap space on a HDD/SSD is called virtual memory (VM).
- VM management moves the oldest data out of RAM into swap space on a HDD/SSD.
- The oldest data is moved out to allow a new program to gain RAM access.
- The bit map is updated to reflect the new memory status.

Benefits:

- It gives the illusion of unlimited RAM storage/memory.
- Programs can be larger than physical memory and can still be executed.
- It provides more efficient multi-programming.

Drawbacks:

- There is memory wastage.
- There is the need to buy additional RAM.
- If a HDD is used, one drawback is disk thrashing.
- Disk thrashing can lead to HDD premature failure.

**18 a** It is a method of data storage where data is stored on offsite servers:

- There are three types: public, private and hybrid.
- The same data is often stored on more than one server in case of maintenance or repairs/backing up – this is called data redundancy.

**b** public: storage environments where client and cloud storage provider are separate companies/organisations

private: storage provided by a dedicated environment behind a company firewall; client and cloud storage provider are integrated and act as a single entity

hybrid: a combination of public and private; some sensitive data stored on a private cloud whereas other data can be stored on a public cloud

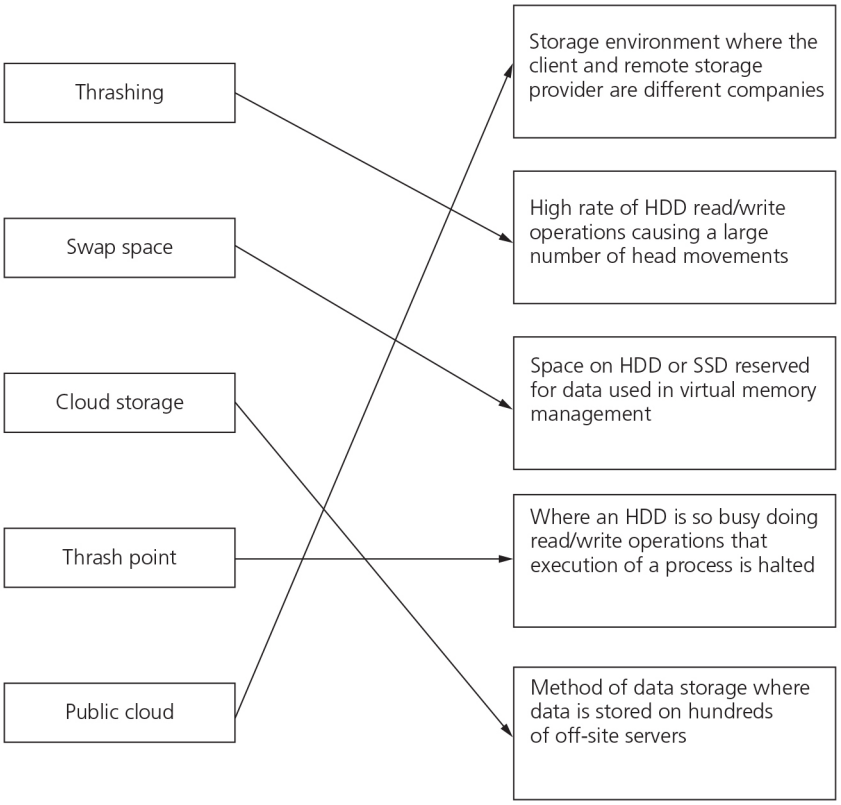
**c** **i** Three from:

- Customer/client files stored on the cloud can be accessed at any time from any device anywhere in the world provided internet access is available.
- There is no need for a customer/client to carry an external storage device with them, or even use the same computer to store and retrieve information.
- The cloud provides the user with remote back-up of data with obvious benefits to alleviate data loss/disaster recovery.
- If a customer/client has a failure of their hard disk or back-up device, cloud storage will allow recovery of their data.
- The cloud system offers almost unlimited storage capacity.

**ii** Two from:

- If the customer/client has a slow or unstable internet connection, they might have many problems accessing or downloading their data/files.
- Costs can be high if large storage capacity is required; it can also be expensive to pay for high download/upload data transfer limits with the customer/client internet service provider (ISP).
- The potential failure of the cloud storage company is always possible – this poses a risk of loss of all back-up data.

**19**



**20 a i** NIC

**ii** MAC

**iii** IP

**iv** router

**v** firewall

**b i** It is a temporary IP address assigned to a device which changes each time a device logs onto the internet. It uses DHCP to assign the temporary IP addresses.

**ii**

| **Dynamic IP address** | **Static IP address** |
|---|---|
| Greater privacy because it changes each time a user logs on | Because a static IP address doesn't change, it allows each device to be fully traceable |
| A dynamic IP adress can be an issue when using, for example, VoIP because this type of addressing is less reliable because it can disconnect and change the IP address causing the VoIP connection to fail | It allows for faster upload and download speeds |
| | It is more expensive to maintain because the device must be constantly running so that information is always available |

**c i** 1 = computer

2 = switch

3 = router

4 = external network (e.g. internet)

**ii**
- It enables data packets to be routed between different networks, for example, joining a LAN to a WAN.
- A router takes data transmitted in one format from a network (using one protocol) and converts the data to a protocol and format understood by another network.
- A router inspects data packets sent to it from any computer or connected network.
- Because all computers on the same network have the same part of an IP address, the router can send data packets to the correct switch for onward delivery to the correct MAC address.

**21 a** internet service provider

**b** a set of rules agreed by devices using the internet

**c**
- IPv4 uses 32-bit addresses …
- … whereas IPv6 uses 128-bit addresses.
- for example: 190.188.0.250 (IPv4)
  fff0:a8fb:7a88:0fff:3d22:2088:66fb:f0fa (IPv6)
- There is less risk of IP address collision with IPv6.
- IPv6 has built-in authentication.
- IPv6 is a more modern/recent IP address protocol.

# 4 Software

**1**

| Software | System (✓) | Application (✓) |
|---|---|---|
| Photo editing software | | ✓ |
| Graphics manipulation software | | ✓ |
| Compiler | ✓ | |
| Spreadsheet software | | ✓ |
| Printer driver | ✓ | |
| QR code reader | | ✓ |
| Anti-virus software | ✓ | |
| Screensaver | ✓ | |

**2** **a** Three from:

- It is a set of programs to control and manage the operation of computer hardware.
- It provides a platform on which software can run.
- It is required to allow hardware and software to run without problems.
- It provides a human computer interface (HCI).
- It provides the control of allocation and usage of hardware resources.

**b** Three from:

- It is used to perform various applications.
- It allows a user to perform specific tasks.
- It may be a single program or a suite of integrated programs.
- The user can execute the software whenever needed.

**c** Three from:

- virus checkers
- defragmentation software
- disk contents analysis/repair
- file compression
- file management
- back-up facility
- security of the system
- screensaver

**3**
- antivirus
- background
- anti-virus
- heuristic checking
- quarantine
- user

- blocks
- sectors
- tracks
- disk defragmenter
- blocks
- contiguous
- head movements

- screensavers
- security systems
- screensaver
- locked

**4** **a** Five from:
- human-computer interface
- multitasking
- error handling
- platform for the running of applications software
- management of user accounts
- managing files
- hardware management
- memory management
- interrupt handling
- security management

**b i** CLI:

- command line interface
- user uses a keyboard to type in commands/instructions …
- … to choose from a menu, open software, and so on
- requires a number of exact commands to do a single task
- user has to learn the commands …
- … and type them in accurately

GUI:

- graphical user interface
- user interacts with the computer using onscreen icons rather than typing commands
- chooses from menus, open software, and so on, by clicking on an icon (using pointing device) or by using finger on a touch screen
- no typing needed
- often uses WIMP environment
- where a windows manager looks after interaction between windows and applications software

**ii**

| **Statement** | **CLI (✓)** | **GUI (✓)** |
|---|---|---|
| The user is in direct communication with the computer | ✓ | |
| The user is limited to the icons shown on the screen | | ✓ |
| The user needs to learn a number of commands to carry out any operation | ✓ | |
| Commands need to be typed in using the correct format and spelling | ✓ | |
| There is no need for the user to learn any commands to use the interface | | ✓ |
| The interface needs a complex operating system, such as *Windows*, to operate, which uses considerable amounts of memory | | ✓ |

**5 a**

- It allows computers to carry out many tasks/processes at a time.
- Each process will share hardware resources under the control of the OS.
- It monitors:
  - allocation of resources to a process for a specific time limit
  - interruption of processes while running
  - prioritisation of a process for resource allocation

**b**
- allows more than one user to log onto the system
- allocates users a part of memory protected by passwords and user IDs
- allows a user to customise

**c**
- ensures integrity, confidentiality and availability of data
- carries out operating system and applications software updates as required
- ensures antivirus (and other security software) is always up to date
- communicates with the firewall to check incoming and outgoing traffic
- maintains privileges to prevent users from entering 'private areas'
- maintains user access rights
- allows for data recovery following loss or corruption of data
- helps prevent illegal intrusion into a computer system

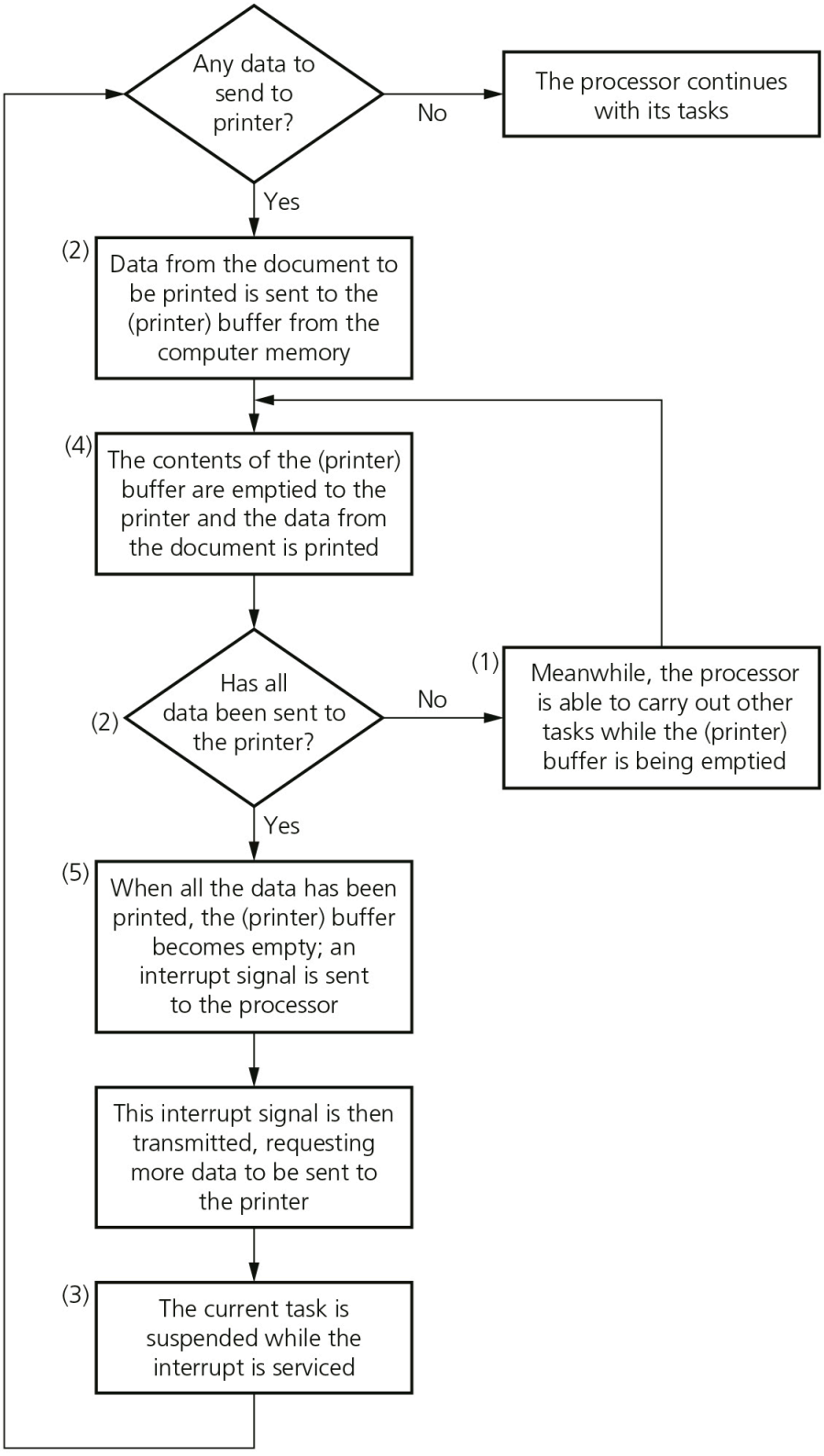
**6 a i** It is a signal sent from a device or software to a CPU/processor requesting attention. The CPU/processor suspends all operations until the interrupt has been serviced.

**ii** Three from:
- a timing signal
- I/O process (for example, a disk drive or printer requesting more data
- a hardware fault (for example, a paper jam in a printer)
- software errors (for example, can't find .exe file or attempt to divide by zero)
- operator input (for example pressing <BREAK> key

**b i** a memory area which stores data temporarily

**ii** Devices run at a slower speed than the CPU/processor:
- Buffers allow devices to carry out their functions while the CPU can carry on with other tasks, therefore greatly improving efficiency, because the CPU is no longer left idle waiting for an output/input device waiting to complete a task.
- Buffers are needed, for example, when streaming from the internet because the internet download speed may be slower than a device's playback speed and a buffer gives temporary storage which fills up allowing data to be available for smooth uninterrupted playback.

**c**



**7**

| | Management type: | | |
|---|---|---|---|
| **Statement** | **Memory** | **Security** | **Hardware** |
| Keeps a track of all memory locations | ✓ | | |
| Ensures that anti-virus software is regularly updated | | ✓ | |
| Prevents competing applications using the same memory locations at the same time | ✓ | | |
| Ensures that the appropriate device driver takes data from memory/file and translates it into a format the device can understand | | | ✓ |
| Management of devices to control the use of queues and buffers holding data temporarily | | | ✓ |
| Receives and handles error messages and interrupts from devices connected to the computer | | | ✓ |
| Manages RAM and allows data to be moved between RAM and devices, such as HDD or SSD | ✓ | | |
| Maintains access rights for all users of a computer system | | ✓ | |

**8** **a** It is software that communicates with the OS and translates data into a format understood by the device.

**b** and **c**

- a collection of information about devices; known as descriptors
- allows the USB bus to ask a newly connected device what it is
- descriptors include vendor ID, product ID and unique serial number

**9** **a** software/instructions programmed on a hardware device

**b** BIOS, videocard, SSD, CD/DVD drive are common examples.

**10** **a** In any order:

- Programs are easier to write.
- Programs take less time to write.
- Programs are easier to maintain.

**b** A programmer may be writing a program that needs to perform a task very quickly. If he uses a low-level language, he can ensure only essential programming statements are included. This would reduce the time taken to execute the task.

**c** Type of language: assembly language

Reasons: Steve is writing a program that uses specialist hardware to control the lighting and there are no high-level programming commands available to drive this hardware.

**11**
- language
- machine code
- assembler
- high-level
- language
- machine code
- translators
- high-level
- compilers
- interpreters

The last two answers can appear in either order.

**12 a** A compiler translates a program written in a high-level language into a machine code program. The whole program is translated.

**b** An interpreter executes a program written in a high-level language by translating, then executing each line of the program.

**c** An assembler translates a program written in assembly language into a machine code program. The whole program is translated.

**13 a i** to translate the final program that is going to be used repeatedly

**ii** while the program is being developed

**b** In any order:
- It is easier to edit programs during development.
- It is faster to debug programs during development.

**c** In any order:
- Once translated, programs do not need the compiler to execute and only need translating once.
- Once translated, programs take up less space in memory during execution.

**14 a** An integrated development environment (IDE) is used by programmers to aid in the writing, editing and development of programs.

**b** Three from:
- code editor
- translator
- auto-completion
- auto-correction
- pretty printing

**c** Error diagnostics and debuggers allow the programmer to run the program under development in a controlled environment. For example, a separate report window can be used to display the values of each variable as the program is running.

# 5 The internet and cyber security

**1 a**

| **Internet** | **World wide web (www)** |
|---|---|
| Users can send and receive emails | It is a collection of multimedia web pages and other information on websites |
| Allows online chatting (via text, audio and video) | Web pages are written using hypertext mark-up language (html) |
| Makes use of transmission protocols (TCP) and internet protocols (IP) | Uniform resource locators (URLs) are used to specify the locations of web pages |
| It is a worldwide collection of interconnected networks and devices | Web resources are accessed by web browsers |
| | The www uses the internet to access information from web servers |
| | Makes use of the http(s) protocol |

**b i** https

**ii** www

**iii** .com

**iv** comp_science_sample

**c** Three from:

- They have a home page.
- They can store a user's favourite websites/web pages (used as a bookmark).
- They keep a history of websites visited by the user (user history).
- They have the ability to allow the user to navigate forwards and backwards through websites/web pages already opened; many webpages can be open at the same time (navigation).
- They make use of hyperlinks that allow navigation between websites and web pages; links are shown in one of two ways:
  - either the website is underlined and requires <ctrl> + <click> to follow the link
  - or a small pointed finger shows under the name of the website link to highlight it
- They make use of cookies.
- Data is stored as a cache.
- They translate HTML and display the result of the translation on the user's device.
- They make use of JavaScript.
- They use an address bar.

**2** order: 2, 4, 5, 1, 6, 3

**3 a**
- a cookie that is stored temporarily on a computer
- cookie is deleted when the browser is closed or the website session terminated

**b**
- a cookie that is stored on a user's HDD/SSD
- a cookie that is only deleted when its expiry date is reached or it is deleted by the user

**c** Three from:
- They allow a website to remember a user's details.
- They allow a website to recognise a user every time they visit the website.
- They can save a user's items in a virtual shopping basket.
- They can track a user's internet habits and their browsing history or favourites (bookmarks).
- They can target users with advertising which matches previous buying/surfing habits.
- They can store user preferences.
- They allow different languages to be used on the webpage automatically as soon as a user logs onto the website.
- They allow progress in online games/quizzes to be stored.

**4 a**

| **Blockchaining statement** | **True (✓)** | **False (✓)** |
|---|---|---|
| All digital currency systems use blockchaining | | ✓ |
| Blockchaining uses a decentralised database | ✓ | |
| The last block in a blockchain is known as the 'genesis block' | | ✓ |
| New hash values are only generated when data in a block is altered | | ✓ |
| Tampering of data in a block by a hacker would cause the hash value to change | ✓ | |
| Blocks are 'policed' by network users called 'miners' | ✓ | |

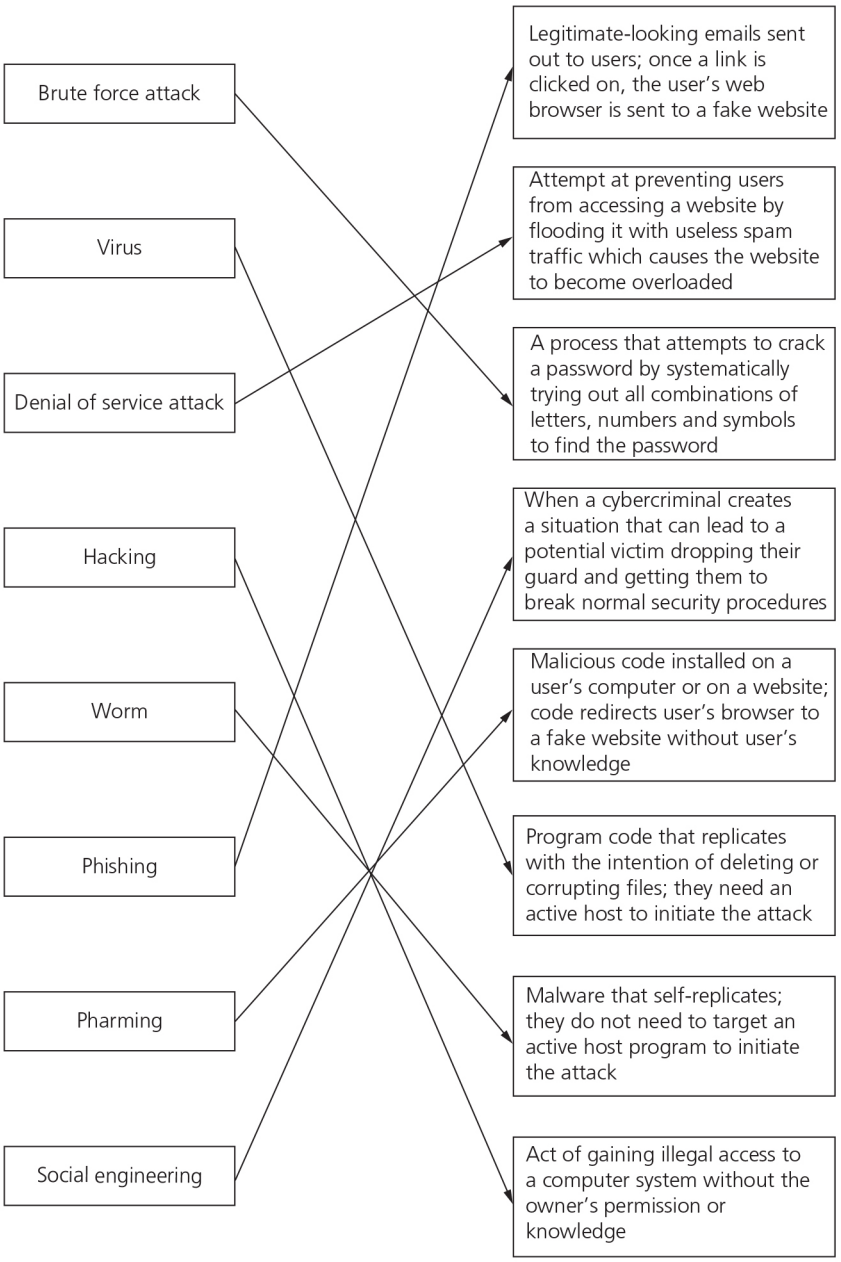
**b** In any order:
- data (for example, name of sender/recipient)
- hash value (a unique 'fingerprint')
- previous hash value (pointing back to previous block in the chain)

**c i** 0000 A4BF 6AB1 34EE FF12 AA00

**ii** Any changes to block '4' will cause the hash value (FF12) to be changed. This means that blocks '5' and '6' and beyond will now be invalid because the chain was broken between '4' and '5' (previous hash value FF12 is no longer valid).

**d**
- Cryptocurrency uses cryptography to track transactions.
- Digital currency uses a central banking system; whereas cryptocurrency is decentralised.
- Cryptocurrency uses block chaining.
- Cryptocurrency transactions are publicly available and therefore all transactions can be tracked.

**5**




**6 a i** Trojan horse: a malicious program often disguised as legitimate-looking software; it replaces all or part of the genuine software with the intent of carrying out some harm to the user's system.

**ii** Adware: software that floods the user's computer with unwanted advertising; usually in the form of 'pop ups' but can frequently appear in the browser's address window redirecting the browser to another website that contains promotional adverts (or sometimes adverts that create a security breach).

**iii** Ransomware: programs that encrypt the data on a user's computer; a decryption key is sent back to the user once they pay a sum of money (the ransom); often sent via a Trojan horse or by social engineering.

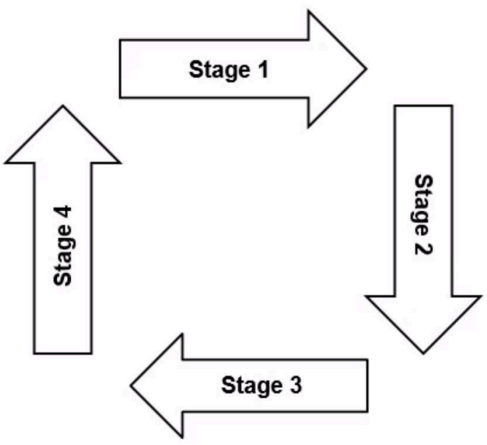
**b i** This occurs when a cybercriminal creates a social situation that can lead to a potential victim 'dropping their guard'. It involves manipulation of people into breaking their normal security protocols by:

- instant messaging
- scareware
- email/phishing scams
- baiting
- bogus phone calls

**ii**

| **Threat used by cybercriminals** | **How the threat is used (include examples)** |
|---|---|
| Instant messaging | • malicious links are embedded into instant messages<br>• for example, an important software upgrade<br>• relies on the user's curiosity |
| Scareware | • this is often done using a pop-up message that claims that the user's computer is infected with a virus<br>• the user is told they need to download the fake antivirus immediately<br>• relies on the user's fear of viruses and other malware |
| Baiting | • the cybercriminal leaves a malware-infected memory stick somewhere where it can be found:<br>  • the finder picks up the memory stick and plugs it into their computer (just to see who it belongs to)<br>  • the finder unwittingly downloads malicious malware<br>• relies on the user's curiosity |
| Phone calls | • a so-called IT professional calls the user on their mobile claiming their device has been compromised in some way<br>• the user is advised to download some special software that allows the cybercriminal to take over the user's device …<br>• … giving them access to personal information<br>• relies on fear of the 'unknown' risks |

**c**




**Stage 1 – the victims are identified; information about victim gathered and method of malware attack decided**

**Stage 2 – at this stage the victim is being targeted (either through email, phone call, Trojan horse and so on; it all depends on who the victim is)**

**Stage 3 – the attack on the victim is now executed allowing the cybercriminal to obtain the information or to cause the disruption decided on at Stage 1**

**Stage 4 – when the cybercriminal has decided they have what they wanted they try to remove all traces of the malware to cover their tracks**

**7 a i** It is software that detects and removes spyware programs installed illegally on a user's computer system.

**ii** Three from:

- It detects and removes spyware already installed on a device.
- It prevents a user from downloading spyware.
- It encrypts files to make the data more secure in case it is 'spied' on.
- It encrypts keyboard strokes to help remove the risk posed by the keylogging aspects of some spyware.
- It blocks access to a user's webcam and microphone (the software stops the spyware from taking over the control of a user's webcam and microphone which can be used to collect information without the user's knowledge).
- It scans for signs that the user's personal information has been stolen and warns the user if this has happened.

**b**

| **Biometric technique** | **Benefits** | **Drawbacks** |
|---|---|---|
| Fingerprint or thumbprint scans | • is one of the most developed biometric techniques<br>• has high accuracy<br>• is very easy to use<br>• has relatively small storage requirements for the biometric data created | • is very intrusive for some people because it is still related to criminal identification<br>• can make mistakes if the skin is dirty or damaged (e.g. cuts) |
| Retina scans | • has very high accuracy<br>• no known way to replicate a person's retina | • is very intrusive<br>• can be relatively slow to verify the retina scan with stored scans<br>• is very expensive to install and set up |
| Voice recognition | • non-intrusive method<br>• verification takes less than 5 seconds<br>• relatively inexpensive technology | • a person's voice can be easily recorded and used for unauthorised access<br>• low accuracy<br>• an illness such as a cold can change a person's voice, making absolute identification difficult or impossible |

**c**

- A microphone picks up verbal commands.
- Certain words, such as 'navigate', 'media', 'open windows', etc, often need to be used.
- The processor processes words by comparing them to those stored on the database.
- Commands are sent to a device to operate satnav, media or window mechanism.
- Signals are sent to actuators to operate motors to open/close windows, and so on.

**8** **a** order: 4, 5, 2, 6, 3, 1

**b** They contain 'patches' that contain software improvements, for example, removing glitches or adding new features; updates may contain security fixes, such as improved anti-malware routines.

**9** Four from:

- email address gives clues, for example, no company will use an email such as '…@gmail.com'
- email address should contain the company name
- tone of email is a clear indication of a scam
- not only spelling mistakes, but the language used and the way the target victim is addressed, for example 'Dear User'
- mis-spelling in a subtle way (i.e. typo squatting)
- suspicious links; the destination address should match the rest of the email
- some links (such as, How To Contact Us) don't work
- look at the domain; for example, large companies would use .com rather than .co or .org

**10** **a** a type of protocol that:

- allows data to be sent and received securely over a network
- encrypts data
- is active when the connection protocol is https or if there is a small green padlock by the website address

**b** order: 2, 4, 1, 5, 3

**c** Three from:

- online banking and financial transactions
- online shopping/commerce
- when sending out software to a restricted list of users
- sending/receiving emails
- using cloud storage facilities
- using VoIP
- when using instant messaging
- when using social networking sites

**11** **a**

- They can filter information in and out of a computer.
- They are the primary defence of any computer system to prevent it from hacking, malware, phishing and pharming.
- They can be hardware or software.

**b** Four from:

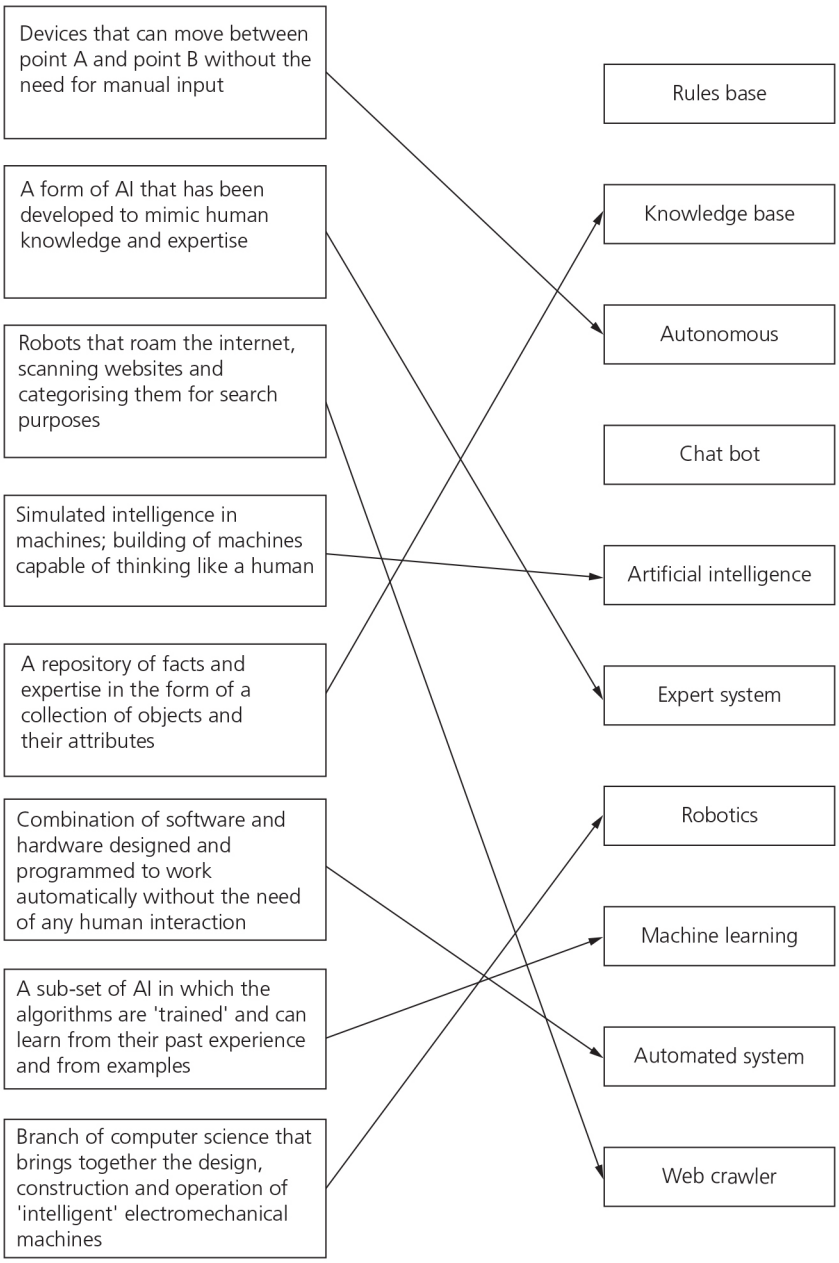
- It is used to examine the 'traffic' between a user's computer (or internal network) and a public network (for example, the internet).
- It checks whether incoming or outgoing data meets a given set of criteria, and if the data fails the criteria, the firewall will block the 'traffic' and give the user (or network manager) a warning that there may be a security issue.
- The firewall can be used to log all incoming and outgoing 'traffic' to allow later interrogation by the user (or network manager).
- Criteria can be set so that the firewall prevents access to certain undesirable sites; the firewall can keep a list of all undesirable IP addresses.
- Alternatively, the firewall can be set to only allow access to known and trusted IP addresses.
- It is therefore possible for firewalls to help prevent viruses or hackers from entering the user's computer (or internal network).
- The user is warned if some software on their system is trying to access an external data source (for example, automatic software upgrade); the user is given the option of allowing it to go ahead or request that such access is denied.

# 6 Automated and emerging technologies

**1**

- expert systems
- inference
- user interface
- dialogue boxes
- explanation system
- inference engine
- knowledge base
- inference engine
- inference rules
- rules base
- objects
- attributes
- repository

**2**




**3** **a** It is a combination of software and hardware designed and programmed to work automatically without the need for human intervention.

**b** An input device that takes readings from its surroundings and sends the data to a microprocessor/computer.

**c** Three from:

- industrial uses
- transport systems
- agriculture/farming
- weather forecasting
- gaming
- lighting systems
- science/research/laboratory work

**d** Three from:

- They are much faster than a human operator to take any necessary action.
- They keep humans away from potentially dangerous environments.
- The process can be run under optimum conditions.
- They are less expensive in the long run.

**e** Three from:

- They are expensive to set up initially.
- It is always possible for a situation to arise which was not considered when testing and developing the system.
- They are subject to cyber attacks.
- They require enhanced maintenance.

**4 a** OCR

**b**

- A pressure sensor on the ground recognises presence of a vehicle.
- The data is sent back to computer which then sends a signal …
- … to operate the camera.
- The camera photographs the front of the vehicle.
- Software converts characters on the number plate into electronic values which are then compared to a database.
- If the vehicle number plate matches data on the database, then the computer sends a signal to an actuator …
- … to operate a motor to raise the barrier.
- On exit, the same procedure as above is carried out to see if the vehicle was allowed to park.

**c i**

- There is no need for any manual checks.
- It can operate 24/7.
- It has improved security because only recognised vehicles are allowed entry.

**ii**

- The number plate stored with manufacturer of vehicle/colour of vehicle is also stored on the database.
- There will be a vehicle manufacturer badge as well as number plate read by camera.
- It is possible to have additional security such as RFID in a vehicle.

**5 a i** cameras:

- can gauge the size of the parking space
- feed back images to driver to check parking procedure

**ii** sensors:

- can detect the presence of other vehicles
- can detect items such as kerbs, people, lamp posts, trees, and so on

iii actuators:

- operate brakes
- operate steering
- operate throttle/accelerator

**b** To prevent the driver exceeding a set speed:

- Sensors in the front bumper of car detect the vehicle in front.
- Data is sent to the microprocessor (converted to digital by ADC if necessary).
- The microprocessor calculates the distance between vehicles.
- Sensors on the speedometer drive constantly send signals to the microprocessor.
- The microprocessor compares the speed to a set speed.
- If speed is equal to set speed no action is taken.
- If speed > set speed, signals are sent to actuators to operate brakes and reduce throttle.
- If speed < set speed, microprocessor sends signals to actuators to increase throttle.
- This process loop is continued until speed is within set speed.
- To prevent constant braking and accelerating, the microprocessor allows a 5 kph margin in all calculations.

To prevent the car getting too close to the vehicle in front of it:

- The microprocessor determines if the distance between vehicles is equal to the safe distance for set speed calculated above.
- If distance < safe distance, the microprocessor sends signals to operate brakes and reduce throttle …
- … and signal is also sent to a warning buzzer to inform the driver.
- If distance >= safe distance, the microprocessor checks speed value …
- … if speed = set speed then no action is taken …
- … otherwise, the first loop is checked to see if the car is doing the set speed value.
- This process loop is continued until vehicle is at a safe distance …
- … to prevent constant braking, a safety margin is built into calculations.

**6 a i**

- level sensor – to measure the amount of liquid added to a batch
- temperature sensor – to ensure the reaction mixture has the correct temperature of 35°C maintained
- light sensor – intensity of light passing through a reaction mixture will change as the colour changes

**ii**

- infrared/motion sensor – detects the presence of visitors in the room
- light sensor – to automatically switch off room lights once the display starts

**iii**

- pressure sensor – to detect a passenger in a doorway
- infrared sensor – to detect the proximity of a passenger
- camera – to relay data back to the driver or to the control centre

**b**

| Statements | True (✓) | False (✓) |
|---|---|---|
| Automated systems lead to less consistent results or less consistent products | | ✓ |
| Automated systems are more expensive to set up than traditional manual systems | ✓ | |
| Automated systems could be quickly overwhelmed by the amount of data presented to it | | ✓ |
| Automated systems are inherently less safe than manual systems | | ✓ |
| Automated systems generally require enhanced maintenance when compared to manual systems | ✓ | |
| Automated systems allow processes to run at optimum conditions at all times | ✓ | |
| Software failures, due to unforeseen conditions, are unlikely to impact on an automated system | | ✓ |
| Automated systems will react more quickly to unusual process conditions than a manual system | ✓ | |

**7 a** 1 = user interface

2 = inference engine

3 = knowledge base

**b i** objects

**ii** taxi cab

**c**

- Information needs to be gathered from human experts or from written sources such as textbooks, research papers or the internet.
- Information gathered is used to populate the knowledge base which first needs to be created.
- A rules base needs to be created; this is made up of a series of inference rules so that the inference engine can draw conclusions.
- The inference engine itself needs to be set up; it is a complex system because it is the main processing element making reasoned conclusions from data in the knowledge base.
- The user interface needs to be developed to allow the user and expert system to communicate.

**8 a i** the simulation of human behaviour – such as recognising objects, problem-solving, decision-making and language skills – by a computer, essentially:

- a collection of rules and data
- the ability to reason, learn and adapt to external stimuli

**ii** a sub-set of AI, in which algorithms are trained to learn from past experiences and examples

**b**

| **AI** | **Machine learning** |
|---|---|
| It represents simulated intelligence in machines | This is the practice of getting machines to make decisions without being programmed to do so |
| The aim is to build machines which are capable of thinking like humans | The aim is to make machines that learn through data acquisition, so that they can solve new problems |

**9 a** C

**b** E

**c** B

**d** A

**e** D

**10**

| **Advantages of autonomous trains** | **Disadvantages of autonomous trains** |
|---|---|
| improved punctuality | the ever-present fear of hacking into the vehicle's control system |
| reduced running costs (fewer staff are required) | system doesn't work well with very busy services (at the moment) |
| improved safety because human error is removed | high capital costs and operational costs initially (that is, buying the trains, expensive signalling and control equipment and the need to train staff) |
| minimises energy consumption because there is better control of speed and provides for a more optimum service with fewer delays; delayed trains stuck in stations still use energy | ensuring that passenger behaviour is acceptable particularly during busy times (for example, jamming doors open on trains, standing too near the edge of platforms, and so on) |
| it is possible to increase the frequency of trains (automated systems allow for shorter times between trains) | passenger reluctance of the new technology |
| it is easier to change train scheduling (for example, more trains during busier times) | no drivers mean there will be a need for CCTV to monitor railway stations |

| Advantages of autonomous cars and buses | Disadvantages of autonomous cars and buses |
|---|---|
| safer because human error is removed leading to fewer accidents | very expensive system to set up in the first place (high technology requirements) |
| better for the environment because vehicles will operate more efficiently | the ever-present fear of hacking into the vehicle's control system |
| reduced traffic congestion (humans cause 'stop-and-go' traffic known as 'the phantom traffic jam' whereas autonomous vehicles will be better at smoothing out traffic flow, reducing congestion in cities) | security and safety issues (software glitches could be catastrophic; software updates would need to be carefully controlled to avoid potential disasters) |
| increased lane capacity (research shows that autonomous vehicles will increase lane capacity by 100% and increase average speeds by 20%, due to better braking and acceleration responses together with optimised distance between vehicles) | the need to make sure the system is well-maintained at all times; cameras need to be kept clean so that they don't give false results; sensors could fail to function in heavy snowfall or blizzard conditions (radar or ultrasonic signals could be deflected by heavy snow particles) |
| reduced travel times (for the reasons above) therefore less commuting time | driver and passenger reluctance of the new technology |
| stress-free parking for motorists (the car will find car parking on its own and then self-park) | reduction in the need for taxis could lead to unemployment (imagine New York without its famous yellow cabs!) |