



Coimisiún na Scrúduithe Stáit
State Examinations Commission

Leaving Certificate 2021

Marking Scheme

Computer Science

Higher Level

Note to teachers and students on the use of published marking schemes

Marking schemes published by the State Examinations Commission are not intended to be standalone documents. They are an essential resource for examiners who receive training in the correct interpretation and application of the scheme. This training involves, among other things, marking samples of student work and discussing the marks awarded, so as to clarify the correct application of the scheme. The work of examiners is subsequently monitored by Advising Examiners to ensure consistent and accurate application of the marking scheme. This process is overseen by the Chief Examiner, usually assisted by a Chief Advising Examiner. The Chief Examiner is the final authority regarding whether or not the marking scheme has been correctly applied to any piece of candidate work.

Marking schemes are working documents. While a draft marking scheme is prepared in advance of the examination, the scheme is not finalised until examiners have applied it to candidates' work and the feedback from all examiners has been collated and considered in light of the full range of responses of candidates, the overall level of difficulty of the examination and the need to maintain consistency in standards from year to year. This published document contains the finalised scheme, as it was applied to all candidates' work.

In the case of marking schemes that include model solutions or answers, it should be noted that these are not intended to be exhaustive. Variations and alternatives may also be acceptable. Examiners must consider all answers on their merits, and will have consulted with their Advising Examiners when in doubt.

Future Marking Schemes

Assumptions about future marking schemes on the basis of past schemes should be avoided. While the underlying assessment principles remain the same, the details of the marking of a particular type of question may change in the context of the contribution of that question to the overall examination in a given year. The Chief Examiner in any given year has the responsibility to determine how best to ensure the fair and accurate assessment of candidates' work and to ensure consistency in the standard of the assessment from year to year. Accordingly, aspects of the structure, detail and application of the marking scheme for a particular examination are subject to change from one year to the next without notice.

Marking Scheme – Section C

Structure of the marking scheme for Section C (Programming)

Candidate responses are marked according to different scales, depending on the types of response anticipated. Scales labelled A divide candidate responses into four categories (correct response, almost correct response, partially correct response, and response of no substantial merit), and so on. The scales and the marks that they generate are summarised in this table:

Scale Label	A	B	C
No. of categories	4	5	6
5 mark scale	0, 2, 3, 5	0, 2, 3, 4, 5	
10 mark scale	0, 3, 7, 10	0, 3, 5, 8, 10	0, 2, 4, 6, 8, 10
15 mark scale		0, 2, 5, 10, 15	

A general descriptor of each point on each scale is given below. More specific directions in relation to interpreting the scales in the context of each question are given in the scheme, where necessary.

Marking scales – level descriptors

A-scales (4 categories)

- response of no substantial merit
- response with some merit
- almost correct response
- correct response

B-scales (5 categories)

- response of no substantial merit
- response with some merit
- response about half-right
- almost correct response
- correct response

C-scales (6 categories)

- response of no substantial merit
- response with some merit
- response about half-right
- response more than half-right
- almost correct response
- correct response

Section A**Short Answer Questions****30 marks**

Answer any six questions.

Question 1**5 marks**

Output
x is 3
7 3
6 8
y is y

First full correct response 2 marks
Each additional correct response 1 mark

Question 2**3 + 2(1,1) marks****(a)**

- The circuits in a computer's processor are made up of transistors. A transistor is a switch that is activated by the electronic signals it receives. Signals can be 0V or 5V. The digits 1 and 0 used in binary reflect the on and off states of a transistor.
- As there are only two possible states, binary is more reliable than any other number systems.

Very good explanation - clear understanding demonstrated 3 marks
Fair explanation - limited understanding 1 mark

(b)

- (i) $2^4 = 16$ unique pieces of information can be represented using four-bits.

Correct 1 mark

- (ii) $\log_2 8 = 3$ bits can represent 8 unique pieces of information.

Correct 1 mark

Question 3**2(1,1) +3 marks****(a)**

- RAM can be written, whereas ROM is read-only.
- RAM chips can be read faster than ROM.
- ROM is non-volatile storage (does not require a constant source of power to retain information stored on it) whereas RAM is volatile and requires a constant source of power to retain information.
- Data/information in ROM is permanent whereas RAM is used to store temporary information.
- CPU cannot access data that is stored in ROM directly – must be transferred to RAM first.
- ROM is used primarily in the start-up process of a computer, whereas RAM is used in the normal operations of a computer after starting up and loading the operating system.
- Capacity. RAM can store multiple gigabytes (GB) of data (typical range is 1-256GB per chip). ROM typically stores only several megabytes (MB) of data, typically 4-8MB per chip.
- Physically RAM chips are bigger than ROM chips (of the same capacity).
- The cost of RAM chips tends to be higher than ROM.
- Or any similar relevant difference.

Each correct response 1 mark

(b)

- More RAM means more applications can be loaded in RAM at the same time. This means the CPU spends less time loading RAM from secondary storage and/or paging/thrashing. This in turn means that the CPU can spend more time running user applications.
- Better performance means applications run faster / quicker response times for user.

Very good explanation - clear understanding demonstrated

3 marks

Fair explanation - limited understanding

1 mark

Question 4**2+3 marks****(a)**

- The method does not work because the contents of **x** are overwritten (lost) after the first assignment.
- A temporary variable is needed.

Good description - clear information

2 marks

(b)

- **Use a temporary variable**
temp = x
x = y
y = temp
- **or, use Python's canonical swap**
x, y = y, x
- **or, use addition/subtraction operators**
x = x + y
y = x - y
x = x - y
- **or, use multiplication/division operators**
x = x * y
y = x / y
x = x / y
- **or any other valid solution**

Very good description - clear understanding demonstrated

3 marks

Fair description - limited understanding

1 mark

Question 5

3 + 2 marks

(a)

n	total	count
0	0	0
7	7	1
3	10	2
8	18	3

First correct column 2 marks

Second column correct 1 mark

OR

Each correct row 1 mark

OR

One correct value 1 mark

(b) 18/3=6

Full correct response 2 marks

Question 6**5 marks**

- Family discount should be allowed for situations where only 1 parent (adult) is travelling with a child. Could be perceived to discriminate against single-parent families.
- You could have any number of children travelling and only a single adult and get no discount.
- If num_adults ≥ 10 and num_children > 0 (could be 99 children) the discount is family - should be large group discount (as opposed to family discount).
- Children don't contribute to large or small group discounts.
- Any valid scenario.

Scenario 1 (best scenario). Good description – clear understanding 3 mark

Scenario 2 (2nd best scenario). Good description – clear understanding 2 marks

Question 7**2+3 marks****(a)**

- HTTP is unsecured while HTTPS is secured.
- HTTP sends data over port 80 while HTTPS uses port 443.
- HTTP operates at application layer, while HTTPS operates at transport layer.
- No SSL certificates are required for HTTP, with HTTPS it is required that you have an SSL certificate and it is signed by a CA.

Good description - clear information 2 marks

(b)

TCP breaks messages into chunks called packets and then passes these chunks onto the IP layer. At the receiving end the TCP software reassembles the packets into the correct order (based on an assigned sequence number). Reliability is achieved by a system of acknowledgments and timeouts. If an acknowledgement is not received within the required timeout the TCP software resends individual packets or the entire message.

Very good explanation - clear understanding demonstrated 3 marks

Fair explanation - limited understanding 1 mark

Question 8**2+3 marks****(a)**

- ASCII is a 7-bit system – cannot represent more than 128 characters. Extended ASCII uses an extra bit meaning it can cater for up to 256 different characters. ASCII was invented in the 1960's (first published in 1963) and designed to include the characters that were most commonly used for communication between devices at that time. These included the digits 0-9, upper and lower case letters from the English alphabet (a-z, A-Z), punctuation symbols and a number of non-printing control codes used by old teletype machines.
- Since emoji characters were not 'invented' at the time ASCII was introduced they were not considered for inclusion as part of the ASCII character set.
- Emoji characters are represented using Unicode.

Good explanation - clear information

2 marks

(b) 0001 1111 0100 0100 1101

Correct 3 marks

Half correct 2 marks

Response with some merit 1 mark

Question 9**2+3 marks****(a)**

- An OS is the software that controls the hardware of a computer.
- Acts as an interface between other software and the hardware.
- Acts as an interface between the user and the machine.

Good description - clear information

2 marks

(b)

- I/O Management
 - Controls the user interface (handles graphics, screen sizes, resolutions etc.).
 - Provides access to peripheral devices (through device drivers).
- File System
 - Keeps track of where files are located (e.g. maintains the file allocation table in FAT systems).
 - Controls access to files (e.g. sequential vs direct access).
 - Handles file security.
 - Implements disk scheduling policy (e.g. first-come, first-served).
- Memory Management
 - Allocation of RAM.

- Loads data in from secondary to primary storage.
- Swaps data out from primary to secondary.
- **Processor Scheduling**
 - Decides which job to run next and for how long (e.g. first-come, first-served, shortest job first, round robin).
 - Maintains the state of each process (e.g. ready/waiting/running/ended).
 - Deadlock avoidance.
 - Handles multitasking.
 - Handles multiple users.

For each layer up to a total possible maximum of 3 marks:

Good explanation - clear information 2 marks

Fair explanation - limited understanding 1 mark

Question 10

2+3 marks

(a)

- To agree requirements with customer.
- To ensure system/project is delivered on time and within budget.
- To oversee project schedule – planning - set key dates/milestones.
- To resource project – staffing, equipment, finance etc.
- To assign tasks related to design, implementation, testing etc.
- To communicate with and motivate team and ongoing liaison with customer.
- To monitor project progress.
- Any relevant task.

For each correctly stated task 1 mark

(b)

- High level languages such as Python and JavaScript use English like words e.g. while, if. Programs written in these languages are translated into machine code using a compiler or interpreter. High level languages are machine independent.
- Low level languages are used to write code for a specific processor architecture. The instruction is constrained by a processor's instruction set. Examples are assembly languages and machine code (code written only using 1's and 0's).

Very good description - clear understanding demonstrated

3 marks

Fair description - limited understanding

1 mark

Question 11**2+3 marks****(a)**

- To test the feasibility of some idea (i.e. testing ideas before committing to them. Refinements can be made more quickly, more safely and for less money e.g. is it worthwhile to vaccinate?
- To make predictions/demonstrate emergent behaviour (e.g. population growth, the spread of a virus, infection rates) so that decisions can be better informed (e.g. where to build hospitals, roads, schools or whether it is necessary to vaccinate against the spread of a virus).
- To run simulations and be used as a basis for discussion and gaining a better understanding of a phenomena.
- To enable solutions to problems that are difficult to solve analytically (e.g. because of scale or complexity).
- Or similar.

For each correctly stated benefit 1 mark

(b)

- Agent-based modelling (ABM) for COVID 19 could have behavioural rules corresponding to infection conditions and also include an individual profile for each agent, which defines its main social characteristics and health conditions used during its interactions.
- ABMs can be used to predict outcomes for certain scenarios thereby allowing policy makers to make informed decisions such as those relating to social distancing, washing hands, setting lockdowns, easing restrictions, levels 1-5, crowd controls, indoor vs. outdoor activities, foreign travel etc.

Very good explanation - clear understanding demonstrated 3 marks

Fair explanation - limited understanding 1 mark

Question 12**2+3 marks****(a)**

The value of a primary key (PK) must be unique:

- `dog_name` would not be a good PK because a duplicate value exists i.e. *fido*.
- `breed` would not be a good PK because duplicates *could* exist.
- both fields could potentially contain duplicates.

For each correctly stated reason 1 mark

(b)

- A foreign key(FK) links two tables. It provides the relationship between two tables. In this case if the table shown was split into two separate tables – one for owners and one for dogs – the owner_id could be used as the PK in the owners table and the FK in the dogs table. The schema is shown below.

owner_id	owner_name	address
1	Joe Murphy	1 main street
2	Ada Traore	9 park ave.
3	James Tidy	7 bond st.

dog_id	dog_name	breed	dob	microchip	owner_id
1	rover	labrador	22/11/2011	Y	1
2	fido	poodle	02/02/2020	Y	1
3	fido	jack russell	15/06/2015	N	2
4	champ	greyhound	01/01/2010	Y	1
5	spot	dalmation	24/08/2007	N	2
6	buddy	rottweiler	21/10/2012	Y	3

Very good explanation - clear understanding demonstrated

3 marks

Fair explanation - limited understanding

1 mark

Section B**Long Questions****30 marks****Question 13****30 (3, 15, 12) marks****(a)****3 (1, 1, 1) marks****(i)****1 mark**

- The second character ('A') is not a digit.
- Any other valid reason.

(ii)**1 mark**

- The routing key must be 3 characters (and not 4).
- The unique ID must be 4 characters (and not 3).
- The unique ID must be after the routing key .
- Any other valid reason.

(iii)**1 mark**

- The first character ('8') is not a letter.
- The second character ('X') is not a digit.
- The third character ('T') is not a digit.
- Any other valid reason.

(b)**15 (2, 2, 4, 2, 5) marks****(i)****2 marks**

A validation check is a test carried out by a program to make sure data is in the correct format. In the context of Eircode, a validation check will make sure it conforms to the rules for the Routing Key and the Unique Identifier provided at the start of the question.

Good explanation - clear understanding demonstrated

2 marks

(ii)

2 marks

A test case would be any value passed into the function.

The test case e.g. 123 4568 would be passed into the function and the result would be compared to an expected result.

If the Eircode was valid the result of the test case would be True; False otherwise.

Good explanation - clear understanding demonstrated

2 marks

(iii)

4 marks

Unit Testing

- Usually carried out by the programmer.
- The purpose of unit testing is to test specific units of code.
- Test cases are designed to trigger all execution paths in the code.
- Typically automated.
- A form of white box testing (as testers are familiar with the code being tested).

System Testing

- Usually carried out by testers.
- The overall aim of system testing is to determine that the system meets the user requirements (i.e. it does what it is supposed/designed to do).
- System testing includes testing how the system operates under certain abnormal conditions e.g. after a power cut, by cutting off internet access, under stressed conditions.
- Typically carried out by testers (proxies for end-users).
- A form of black box testing (as testers are unfamiliar with the code being tested).

For each of Unit Testing/System Testing

Good explanation - clear understanding demonstrated

2 marks

(iv)

2 marks

- The function only looks at the first three characters and the last four characters – it does not check for length or look for any characters in between .

Very good explanation - clear understanding demonstrated

2 marks

(v)

5 marks

Regression testing is important because it ensures that a change to the code does not result in breaking some pieces of code that had already been tested. It ensures that no new bugs are introduced as a result of implementing a software update.

Good explanation - clear understanding demonstrated

5 marks

(c)

12 (2, 4, 3, 1, 2) marks

(i)

2 marks

The Python code checks whether the first character of the Eircode passed in is a letter or not. If it is not a letter (A-Z or a-z) the condition will be True and the function will return False

Good explanation - clear understanding demonstrated

2 marks

(ii)

4 marks

P	Q	not P	not Q	not P or not Q
False	False	True	True	True
False	True	True	False	True
True	False	False	True	True
True	True	False	False	False

1 Mark per correct row

OR

2 Marks for 1st fully correct column

1 Mark for 2nd and 3rd correct column

OR

1 mark for more than 2 correct values in each column

(iii)

3 marks

P	Q	P and Q	not (P and Q)
False	False	False	True
False	True	False	True
True	False	False	True
True	True	True	False

Every value correct

3 marks

1 mark for each correct row (up to a max. of 2)

1 mark for more than 2 correct values in each column

1 mark for any correct value

(iv)

1 mark

```
if not (test_eircode[1].isdigit() and test_eircode[2].isdigit()):
```

OR

```
if not (P and Q):
```

Correct response

1 mark

(v)

2 marks

Slicing could be used to extract the 2nd and 3rd characters and test them together (as a slice) for digits (as opposed to testing them individually).

OR

```
if not (test_eircode[1:3].isdigit()):
```

Very good explanation - clear understanding demonstrated

2 marks

Question 14

30 (12, 13, 5) marks

(a)

12 (2, 2, 2, 2, 2, 2) marks

(i)

2 marks

3 is a losing position because the only options are to take 1 or 2 matchsticks. Both options leave opponent in a winning position as follows:

- If player takes 1, it leaves 2 for my opponent (who can then take these 2 to win).
- if player takes 2, it leaves 1 which is also a winning position for my opponent.

Very good explanation - clear understanding demonstrated

2 marks

(ii)

2 marks

4 is a winning position because player can take 1 matchstick to leave their opponent with 3, which is a losing position (as per part (i) of the question).

Very good explanation - clear understanding demonstrated

2 marks

(iii)

2 marks

5 is winning position as a move to take two matchsticks leaves the next player in a losing position.

6 is a losing position as any move (take 1 or 2) places the next player in a winning position

No. of matchsticks remaining	0	1	2	3	4	5	6
Position (W or L)	L	W	W	L	W	W	L

Each correct response

1 mark

(iv)

2 marks

Decision: I would ask my opponent to go first. (I would go second.)

Reason: 0, 3, 6, 9 etc. are losing positions. All multiples of 3 are losing positions. Since 21 is a multiple of 3 it is a losing position.

Correct decision

1 mark

Justification/Reason

1 mark

(v)

2 marks

My strategy would be to leave my opponent with a multiple of 3 matchsticks on every turn. My initial move would therefore be to take 2 matchsticks as this would leave my opponent with 18 matchsticks.

In other words, my strategy would be to start by taking 2 and then for the rest of the game I would keep taking the opposite number of matches to my opponent i.e. if opponent takes 1 I would take 2; if opponent takes 2 I would take 1.

Very good explanation - clear understanding demonstrated

2 marks

(vi)

2 marks

No. of matchsticks remaining	0	1	2	3	4	5	6	7	8	9
Position (W or L)	L	W	W	W	L	W	W	W	L	W

All W's and L's correct

2 marks

4 correct responses OR all W's or L's correct

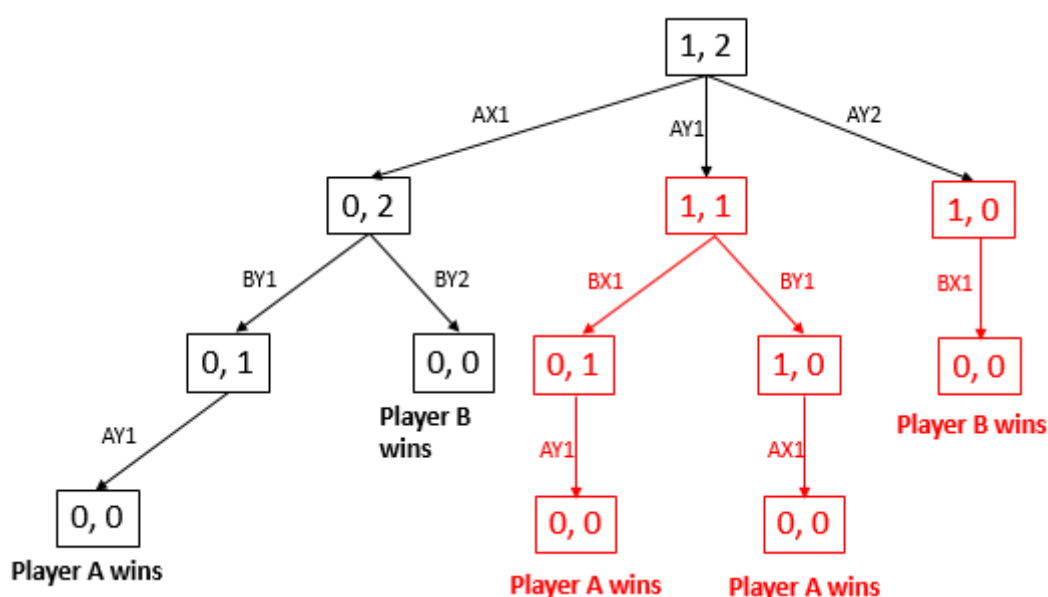
1 mark

(b)

13 (5, 2, 2, 2, 2) marks

(i)

5 marks



Full correct solution

5 marks

3 marks as follows:

1 mark for any one correct pair in path $1,1 \rightarrow 0,1 \rightarrow 0,0 \rightarrow$ player A wins

1 mark for any two correct pairs in path $1,1 \rightarrow 1,0 \rightarrow 0,0 \rightarrow$ player A wins

1 mark for any one correct pair in path $1,0 \rightarrow 0,0 \rightarrow$ player B wins

2 marks for 1st full correct path

2 marks for 2nd full correct path

1 mark for 3rd full correct path

(ii)

2 mark

AY1 is the best move for player A as it is the only move that leads to certain victory for A.

Best move	1 mark
Reason	1 mark

(iii)

2 marks

A winning move for player A from state (2, 3) would be AY1.

This move leaves the opponent – player B - in state (2,2).

From (2,2) B can BX1 \rightarrow (1,2) certain victory for A (as per part (ii)).

From (2,2) B can BY1 \rightarrow (2,1) also certain victory for A.

From (2,2) B can also BX2 \rightarrow (0,2) or BY2 \rightarrow (2,0) both certain victories for A.

Very good description - clear understanding demonstrated 2 marks

(iv)

2 marks

A winning strategy from state (n, m) where $n \neq m$ would be to even the piles. Leave (n, n) or (m, m) .

For $m > n$ this means take $m - n$ matchsticks.

For $m < n$ take $n - m$ matchsticks.

Very good description - clear understanding demonstrated 2 marks

(v)

2 marks

Since (n, n) is a winning position a winning strategy would be to remove one of the piles.

Very good description - clear understanding demonstrated

2 marks

(c)

5 marks

Abstraction

- By ignoring other details, we can focus on one e.g. when faced with $(1,2)$ we play out AX1 without considering other moves.
- Abstraction allows use to use representations for physical actions / objects e.g. $(1,2)$ represents 1 match in pile X and 2 matches in pile Y. A and B represent players. AX1 represents player A taking 1 matchstick from pile X. Even numbers are abstractions e.g. 1 represents a single physical matchstick. The win/loss tables and the tree diagrams are themselves also abstractions for piles of matchsticks. The matchsticks could also be abstractions for other objects e.g. coins, pieces of paper, stocks, shares, commodities etc.
- Any relevant example.

Decomposition

- We can see how by breaking the problem down it is possible to work out every possible outcome. This makes it possible to decide upon a best move.
- In the initial matchstick game if we break the problem down to zero matchsticks and recognise this as a losing position and build up from this we can develop a winning strategy.
- Any relevant example.

Pattern recognition

- By seeing that multiples of 3 are losing positions in the matchstick game it becomes possible to devise a winning strategy.
- By realising that if we always keep the same number of matchsticks in both piles we can generalise to get a winning strategy for (n,n) . Further generalisation can be used to develop a winning strategy for 3 piles such as (n, n, n) or even (l, m, n) and possibly 4 or more piles.
- Any relevant example.

For multiple answers award marks for best answer

Very good explanation - clear understanding demonstrated

5 marks

Good explanation - clear information, lacking demonstration of full understanding

3 marks

Fair explanation - limited understanding

1 mark

Question 15

30 (14, 8, 8) marks

(a)

14 (6, 2, 2, 2, 2) marks

(i)

6 marks

Hardware is the physical components of a computer system – computer components.

Examples processor, memory, storage devices, any input or output device, peripherals, registers, logic gates etc.

Software is the general term used to describe programs/instructions that are executed by the processor.

Examples: Any named application or system software package.

For each hardware/software

Good explanation

1 mark

Each relevant example

1 mark + 1 mark

(ii)

2 marks

Digital sensor: pushbutton, switch, keypad, keyboard or similar.

Analogue sensor: temperature sensor, PIR sensor, accelerometer, humidity, sound, light, CO2 or similar.

Example of digital sensor

1 mark

Example of analogue sensor

1 mark

(iii)

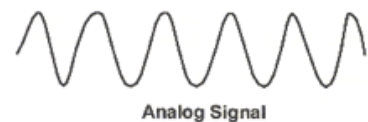
2 marks

Digital input:

- **Have two discrete values (1/0 or ON/OFF).**
- **In electrical circuits these states are represented by voltages (5V = ON and 0V = OFF).**

Analogue input:

- **Have any value within a certain range.**
- **Values continuously vary.**
- **Used to represent continuous data.**



Difference between digital and analogue

1 mark

Diagram of both

1 mark

Definition and diagram of either (but not both)

1 marks

(iv)

2 marks

Real time systems are those that respond to some external stimuli within a stated/minimum time. For example, an alarm will sound immediately (or a light will switch on) when a PIR sensor detects movement.

Very good description - clear understanding demonstrated

2 marks

(v)

2 marks

- Cost – ES are generally cheaper.
- Speed – ES typically run on a dedicated micro-controller.
- Reliability – often less complex and therefore more reliable.
- Automated – once an ES is started it requires minimal user intervention.
- Portability.
- Or similar.

For each relevant advantage (max 2)

1 mark

(b)

8 (2, 2, 4) marks

(i)

2 marks

ES that runs on a smartphone/tablet:

- Camera
- GPS
- Voice recognition systems
- Microphone
- Any similar named example accepted.

Each correct example (max 2)

1 marks

(ii)

2 marks

User interface on mobile devices are often touchscreen, respond to swipes and gestures as well as input from a virtual keyboard and voice.

Universal design refers to design principles that are universally recognised and understood. Refers also to accessibility, adaptive technology and overall user experience.

For each part (UI and UD):

Good description - clear understanding demonstrated

1 mark

(iii)

4 marks

Principles of universal design:

Principle 1 – Equitable in use – design is useful to people with diverse abilities.

Principle 2 – Flexibility in use. It should be possible to configure the ES so that it can be used in multiple ways.

Principle 3 – Simplicity to use – easy to understand.

Principle 4 – Perceptible information - The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Principle 5 - Tolerance for Error The design minimizes hazards and the adverse consequences of accidental or unintended actions.

Principle 6 - Low Physical Effort The design can be used efficiently and comfortably and with a minimum of fatigue.

Principle 7 - Size and Space for Approach and Use Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

For each principle	2 marks
Principle identified	1 mark
Good description - clear understanding demonstrated	1 mark

(c)

8 marks

Relevant stakeholders include end-users/citizens – industry/business owners – government etc.

Potential positive impacts:

on society in areas such as ... → use of social media to communicate/socialise, healthcare/medicine, crime/justice, transport, education, housing, agriculture, environment/climate change, science, exploration

Alternative perspectives:

right of an individual to privacy, misuse of data, profiling, equality, digital divide, use of surveillance tech., polarisation of opinions, democracy/elections, impact on employment (will AI take our jobs), military uses etc.

For each stakeholder	4 marks	
Stakeholder identified	1 mark	
Impact of ES on stakeholder	3 marks	
Very good description - clear understanding demonstrated		3 marks
Fair description – limited understanding		1 mark