N22/3/ITGSX/HP1/ENG/TZ0/XX/M

Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

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Information technology in a global society

Higher level

Paper 1

22 pages

Critical Thinking – explanation, analysis and evaluation

These trigger words often signal critical thinking. The bold words are the key terms in the various criteria.
Explanation – *Because, as a result of, due to, therefore, consequently, for example*
Analysis – *Furthermore, additionally, however, but, conversely, likewise, in addition, on the other hand, whereas*
Evaluation – *My opinion, overall, although, despite, on balance, weighing up*

Examiners should be aware that in some cases, candidates may take a different approach, which if appropriate should be rewarded. If in doubt, check with your team leader.

In the case of an "identify" question read all answers and mark positively up to the maximum marks. Disregard incorrect answers. In all other cases where a question asks for a certain number of facts *eg* "describe two kinds", mark the **first two** correct answers. This could include two descriptions, one description and one identification, or two identifications.

It should be recognized that, given time constraints, answers for part (c) questions are likely to include a much narrower range of issues and concepts than identified in the markband. There is no "correct" answer. Examiners must be prepared to award full marks to answers which synthesize and evaluate even if they do not examine all the stimulus material.

Section A

1. Virtual learning environments

(a) (i) Identify **two** hardware devices that a university lecturer could use to record a lecture. [2]

Answers may include:
- PC/laptop/cellphone
- Microphone
- Webcam / video recording device
- Audio interface

*Award **[1]** for identifying each hardware device up to **[2]**.*

(ii) Identify the steps that a university lecturer may use to upload course material to the virtual learning environment (VLE). [4]

Answers may include:
- Convert the recording into the correct format for uploading (compress if needed).
- Enter URL of VLE landing page / access bookmark / open the university website on a browser.
- Go to the login option.
- Provide login credentials / user ID and password.
- Open the platform (VLE).
- Use drop down menus to select course.
- Upload the course material / drag file from local computer or cloud to the location.

*Award **[1]** for identifying each step up to **[4]**.*

(b) The university needs to choose between open-source software and proprietary software to develop the virtual learning environment (VLE).

Analyse these two options. [6]

Using open-source software:

- Open-source software is often free or low-cost, may allow the university to acquire more software within a limited budget/may suit budget constraints.
- Open-source community is very active and is continually making updates which may be a more efficient mechanism than the staged releases by proprietary software companies.
- The open-source community can often provide immediate help with any software problems.
- Open-source software can be changed or customized to suit the university requirements.
- The source code is available for programmers to modify.
- Open-source software may not have all the options/features needed by the university.
- Using open-source software for the VLE may require hiring more programming staff to upgrade the software.
- Is the open-source software secure?
- The open-source software can be personalized to the university's needs

Using proprietary software:

- Proprietary software includes safeguards such as guarantees / warranties. (support is a new point and is included at the end).
- Most proprietary software can be fully customized to suit the university requirements.
- Companies that provide proprietary software generally provide frequent security updates/patches as they have a vested interest in keeping their product secure.
- The user interface may be a more familiar design as the software is considered as part of a whole package.
- Proprietary software may have a greater range of features/options than open-source software.
- Proprietary software may demand a higher level of investment by the university.
- Manufacturers of proprietary software can provide support and assistance to the company.

Marks	***Level descriptor***
[0]	*No knowledge or understanding of ITGS issues and concepts. No use of appropriate ITGS terminology*
[1–2]	*A limited response that indicates very little understanding of the topic or the reason is not clear. Uses little or no appropriate ITGS terminology. No reference is made to the scenario in the stimulus material. The response is theoretical.*
[3–4]	*A description, unbalanced or partial analysis of the issues related to the use of open source and proprietary software. There is some use of appropriate ITGS terminology in the response.*
[5–6]	*A balanced and detailed analysis of the issues related to the use of open source and proprietary software. Explicit and relevant references are made to the scenario in the stimulus material. There is appropriate ITGS terminology throughout the response.*

(c) Students are in the process of selecting a university to complete their degree. They have two options:

- **Option 1**: A traditional university using face-to-face environments.
- **Option 2**: A university only offering online courses using a virtual learning environment (VLE) platform.

Evaluate these two options. [8]

Answer may include:

Reasons for opting for face-to-face learning

- Students can focus better in F2F environment, learning from home may have distractions.
- Access to resources – students will have better access to resources, e.g. laboratories, library, sports facility, etc.
- Face-to-face learning may be more effective in organizing students and their studies.
- Improve social and interpersonal skills – students may have greater bonding in F2F environment -they will have the ability to interact with professors and students in class physically.
- Students may have better learning opportunities-they can get instant answers, can create a better network with fellow students, the professors.
- the degree earned in F2F environment may carry more value than VLE.
- Unlike VLE, it is easier to enforce compulsory attendance in F2F environment – students are more likely to succeed when they attend classes consistently.
- It is not necessary to have the technology at home.

Reasons for opting for online learning

- Greater access to university courses overseas or in other states as they can study from home.
- Students will have greater flexibility – they can learn at their own pace, in their own time ensuring that they understand each topic before moving on. But this requires motivation and good organizational skills. Can repeat the videos as many times as you want.
- Professors can track students' progress more efficiently using the content access logs and provide more personalized support to them – implies professors are given time to do this.
- University can restrict the availability of any activity, resource or course section according to conditions such as date, grade obtained, group or other activity completion. This may need to be flexible to allow for special cases.
- Learning through VLE would mean that learners can look after their families or work while studying as study can be done at a time that suits them.
- There may be opportunities to collaborate with other students from different countries allowing a global perspective.
- Less expensive – no need for traveling, hostel fees, etc.
- Students will be able to build better organizational skills – but some students may find this challenging.
- Good option for those with physical needs.

In part (c) of this question it is expected there will be a balance in the ITGS terminology between IT technical terminology and the terminology related to social and ethical impacts.

Please see generic markband on page 22.

2. The use of simulators to train military personnel

(a) (i) Identify **two** file formats that could be used to save an image in the simulator. [2]

Answers may include:
- JPEG (or JPG) / joint photographic experts group
- PNG / portable network graphics
- GIF / graphics interchange format
- TIFF / tagged image file format
- PSD / Photoshop document
- RAW / raw image formats

*Award **[1]** for each file format identified up to **[2]**.*

(ii) Define the term *image resolution*. [2]

Answers may include:
- The density of the pixels in the image / the number/amount of dots, or pixels per inch.
- Resolution is measured in pixels per inch (PPI) or dots per inch (DPI).
- The sharpness and clarity of an image (the higher the number of pixels, the greater the resolution).

Quality – only accept if it is related to resolution.

*Award **[1]** for identifying each appropriate statement up to **[2]**.*

(iii) Identify **two** biometric authentication methods that could be used to access the simulator. [2]

Answers may include:
- Fingerprints.
- Facial recognition.
- Voice recognition.
- Iris recognition.
- Retina scan / Eye scan.

*Award **[1]** for identifying each appropriate authentication method up to **[2].***

(b) (i) Distinguish between a model and a simulation. [2]

Answers may include:
- A model is a simplification of the key characteristics, behaviours and functions of the selected system or process.
- A model is based on the algorithms and equations used to capture the behaviour of the system being modelled.
- A model is used to ask 'what if' questions.
- A model is a 'representation' of a real-life object/system.

- A simulation is the actual running of the program that contains these equations or algorithms.
- A simulation, therefore, is the process of running a model / in a simulation, models can be used to study existing or proposed characteristics of a system.
- Simulation takes user input to simulate a situation – to run through various scenarios.

*Award **[1]** for identifying each difference between a model and a simulation, up to **[2]**.*

(ii) Explain why the quality of user documentation is important for the success of the simulator. [4]

Answers may include:
- Good user documentation will make information easily accessible.
- The details included in user documentation may explain the functionality of the simulator to the users. / It helps them have the best product experience.
- It may prevent equipment from being damaged through incorrect use
- It may simplify the understanding of the simulator to new users who can learn to use the simulator quickly.
- It can cut support costs / less dependency on the developer's direct support.
- It may help the users troubleshoot certain common operational issues related to the simulator. / FAQs included in user documentation may have answers to most common issues faced by the users.

Marks	***Level descriptor***
[0]	*No knowledge or understanding of ITGS issues and concepts. No use of appropriate ITGS terminology*
[1–2]	*A limited response that indicates very little understanding of how the quality of user documentation can affect the success of implementation of the newly proposed system. Uses little or no appropriate ITGS terminology. No reference is made to the scenario in the stimulus material.*
[3–4]	*An explanation of how the quality of user documentation can affect the success of implementation of the newly proposed system. Explicit and relevant references are made to the scenario in the stimulus material. There is appropriate ITGS terminology throughout the response.*

(c) To what extent do the benefits of using simulators for training soldiers outweigh the concerns? [8]

Answers may include:

Benefits of using simulators in the training process

- Cost-effective and time-saving.
- It can avoid danger and loss of life / safe environment to learn in / soldiers can be placed into a risk-free environment, which will let them safely carry out any combat drills without any harm.
- Highly immersive experience – VR/AR / Conditions can be varied and outcomes investigated.
- Soldiers can experience a variety of environments and scenarios, e.g. changes in terrain/changes in weather conditions.
- Progress can be measured objectively / soldiers' training performance can be recorded digitally for further analysis or training purposes.
- Simulations can be slowed down to study a soldier's behaviour more closely.
- Simulators allow soldiers to experience any type of vehicle in a far more immersive and realistic way.
- Soldiers can navigate environments native to any part of the world.

Concerns associated with the use of simulators in the training process

- Simulations are not always able to completely recreate real-life situations.
- Use of VR/AR may cause eye strain.
- To simulate a scenario, a thorough understanding is needed and an awareness of all the factors involved. This relies on developers being given complete and accurate data.
- The developer may not be able to visualize real war like situation and may miss out important considerations.
- Simulators can be very expensive and require constant updates and maintenance.
- Trainees need to be trained on how to use the software and/or hardware and this takes up time and costs money.
- No real consequences for mistakes may result in trainees underperforming and not being fully engaged in the training, thus producing inaccurate results.

In part (c) of this question it is expected there will be a balance in the ITGS terminology between IT technical terminology and the terminology related to social and ethical impacts.

Please see generic markband on page 22.

3. Messaging apps*

(a) (i) Identify **two** disadvantages of a user's data being stored on their mobile device. [2]

Answer may include:
- User may lose important data if the device malfunctions.
- User may lose important data if the device is lost/stolen.
- Privacy of user data if device is stolen.
- User may lose important data in case of accidental deletion.
- User may lose important data due to malware/virus.
- Data may take up storage and reduce performance.

*Award **[1]** for identifying each appropriate disadvantage up to **[2]**.*

(ii) Identify **two** characteristics of encrypted data. [2]

Answer may include:
- Encryption translates original data (plain text) into an alternate form (cipher text).
- The encryption process uses an encryption algorithm.
- Encryption keys have a predetermined length / longer keys are more difficult for an attacker to guess than shorter ones.
- A key is used for encrypting and decrypting / to transform the cipher text back into the plaintext.
- An asymmetric encryption, also known as public key encryption, uses two separate keys; a public key and a private key.
- Even if encrypted data is intercepted, it cannot be used/read.

*Award **[1]** for identifying each characteristic of encrypted messages up to **[2]**.*

(iii) Identify **one** advantage for *Tap2Talk* users of receiving notifications. [1]

Answer may include:
- Notifications can keep users updated e.g. promotional offers, social media post by friends/relatives, emergency updates, news.
- It reminds the user to visit the app.
- Notifications can popup on screen even when the app is closed.
- Notifications are generally free for users to receive.

*Award **[1]** for identifying an advantage of receiving notifications up to **[1]**.*

(iv) Identify **one** disadvantage for *Tap2Talk* users of receiving notifications. [1]

Answer may include:
- Frequent notifications such as promotional messages may be irritating for users.
- The notification may come at an awkward time for the user, for example, due to time zone differences.
- The notifications often disappear after they have been accessed or phone is restarted / users may lose access to important notifications.

Note to examiners: Do not accept a disadvantage that people next to you can see notifications.
*Award **[1]** for identifying a disadvantage of receiving notifications up to **[1]**.*

(b) A number of *Tap2Talk* users are concerned about ticking a single check box to agree to the new terms of service and privacy policy (see **Figure 3**).

Explain why *Tap2Talk* users might be concerned about ticking a single check box to agree to the new terms of service and privacy policy. [6]

Answers may include:
- Users will just click the accept check box as it is quick and will not read the policy terms in detail.
- The language in the terms of conditions is so complex that users would not understand it.
- The terms and conditions can be very long and in a very small font size and users will not read the whole document.
- The user needs to use this service therefore they will agree to the terms and conditions almost regardless of what is included in them.
- An unticked checkbox may lead to the termination of services.
- Users know that the privacy policies in their country or region may be different from the company's country or the country where the data is stored.
- New terms of service and privacy policy are not clear or easy to understand
- There is not a validation method to check if the end user is the one accepting the new terms of service and privacy
- There is not a validation method in case terms are accepted by mistake (additional checkbox)
- If the user wants to change his decision during the process, there is no option to go back to previous conditions

Marks	***Level descriptor***
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[1–2]	*A limited response that indicates very little understanding of the topic or the reason is not clear. Uses little or no appropriate ITGS terminology. No reference is made to the scenario in the stimulus material. The response is theoretical.*
[3–4]	*A description, unbalanced or partial analysis of the issues related to the ticking a single check box to agree to the new terms of service and privacy policy. There is some use of appropriate ITGS terminology in the response.*
[5–6]	*A balanced and detailed analysis of the issues related to the ticking a single check box to agree to the new terms of service and privacy policy. Explicit and relevant references are made to the scenario in the stimulus material. There is appropriate ITGS terminology throughout the response.*

(c) *Tap2Talk* has decided to share its users' data with a third party, *GlobalConnect*. This will mean that all user data, such as text messages, locational information and media, will be held in *GlobalConnect*'s database.

Discuss the impacts of this decision for *Tap2Talk* users. [8]

Answer may include:

Advantages for the users

- They can enjoy highly personalized / targeted product suggestions.
- Locational information may let the company combine user's movements with information from other people and deliver services that benefit everyone.
- This may minimize marketing communications irrelevant to them.
- They can receive offers to help them save money on the things they buy often
- They may get recommendations to try something new.
- Users may have better backup capabilities – text message and media stored in *GlobalConnect*'s servers may help the user retrieve them if they are lost/deleted from their device.

Disadvantages for the users

- The pictures, text messages, locational information stored in *GlobalConnect* database may be hacked and misused.
- They may be concerned about the breach of their personal data and the risks associated with identity theft.
- User may not be aware of how their data is going to be used by *GlobalConnect*.
- Users may be concerned about the confidentiality of their data, e.g. they may not be willing to disclose places of their visit to *GlobalConnect* or any third party company.
- Users will not be aware of data sharing agreements *GlobalConnect* has with other companies, and the potential impacts of their data being shared.

In part (c) of this question it is expected there will be a balance in the ITGS terminology between IT technical terminology and the terminology related to social and ethical impacts.

Please see generic markband on page 22.

Section B

4. Artificial intelligence (AI) and machine learning help detect fraud

(a) (i) Identify **two** methods of data collection that could have been used in the stakeholder analysis. [2]

Answers may include:
- Questionnaire/survey
- Focus group
- Interview
- Observation

*Award **[1]** for each method of data collection identified, up to **[2]**.*

(ii) Identify **two** components of a feasibility study. [2]

Answers may include:
- Definition of the problem to be solved
- Defining the project scope
- Determining current market trends (there is an audience willing to purchase the system or service)
- Conducting detailed risk analysis
- Defining technical requirements
- Cost analysis for the project
- Analysis/evaluation of the outcomes
- Agreed course of action
- Conducting SWOT analysis (strengths, weaknesses, opportunities, threats)

*Award **[1]** for each component of a feasibility study identified, up to **[2]**.*

(iii) Describe the difference between supervised machine learning and unsupervised machine learning. [2]

Answers may include:
- Supervised learning – algorithm learns with a specific dataset provided by a programmer, provides answers that can be used to evaluate its accuracy on training data.
- Unsupervised learning – provides unlabeled data that the algorithm tries to make sense of by extracting features and patterns / it is a self-learning technique without human intervention.

*Award **[1]** for either defining one term or a superficial description of the differences between supervised machine learning and unsupervised machine learning.*

*Award **[2]** for a description of the differences between supervised machine learning and unsupervised machine learning.*

***Note:** It is acceptable to correctly define each term for **[2]**.*

(b) Explain the difference between an artificial neural network (ANN) and an expert system. [6]

Answers may include:

- ANNs are based on statistical modeling of data which can process data input from multiple machine learning algorithms.
- ANN have the ability to learn themselves and produce output that is not limited to the input provided.
- ANNs learn from examples so they can work through real-time events.
- ANNs can perform multiple tasks in parallel without affecting the system performance.
- Input is stored in its own network not a database, so the loss of data does not affect how it works.
- Machine learning can adapt to changes in circumstances more rapidly.
- Expert systems are rule based systems which means their capabilities are restricted to the information within them – ANNs can answer new questions.
- Expert system uses if-then statements when doing inference which cannot accommodate possible answers that are not binary.
- Expert systems require new rules to be created to increase their capabilities whereas ANNs can learn from examples.

Marks	***Level descriptor***
[0]	*No knowledge or understanding of ITGS issues and concepts. No use of appropriate ITGS terminology*
[1–2]	*A limited response that indicates very little understanding of why machine learning would be used rather than an expert system. Uses little or no appropriate ITGS terminology. No reference is made to the scenario in the stimulus material.*
[3–4]	*A description of why machine learning would be used rather than an expert system. Some implicit references are made to the scenario in the stimulus material. Some ITGS terminology in places.*
[5–6]	*An explanation of why machine learning would be used rather than an expert system. Explicit and relevant references are made to the scenario in the stimulus material. There is appropriate ITGS terminology throughout the response.*

(c) Discuss the impact on *Coco Financial* of using artificial intelligence (AI) algorithms to detect fraud. [8]

Answers may include:

Advantages of using AI algorithms to detect fraud
- Can collect data faster using this method – providing faster results.
- Error rate is much lower – the algorithms follow rules and does not deviate from them.
- Carries out data analysis – provides information enabling users to see trends.
- Eliminates the straight forward cases – allow employees at *Coco Financial* to focus on unusual cases that do not appear solvable by the AI.
- Increased success of the AI algorithms will lead to the AI system being trusted – more cases checked using it (a virtuous circle).

Disadvantages of using AI algorithms to detect fraud
- It takes time and money to train the software.
- AI algorithms may provide results but not the analysis that leads to the results.
- AI algorithms do not provide a human perspective – information may be skewed / analysed using incorrect algorithmic assumptions.
- There may be algorithmic bias.
- Employees at *Coco Financial* will still need to check the data being input to ensure it is accurate or incorrect data input will lead to incorrect outcomes.
- Employees at *Coco Financial* will need to ensure that external factors such as changes in the law are incorporated.
- Deskilling of employees may take place.
- System failures may occur.

In part (c) of this question it is expected there will be a balance in the ITGS terminology between IT technical terminology and the terminology related to social and ethical impacts.

Please see generic markband on page 22.

5. Cybersecurity: software testing

(a) (i) Identify **two** features of artificial intelligence (AI). [2]

Answers may include:
- Simulation of human intelligence
- Able to perform tasks that normally require human intelligence
- Make decisions based on data learned from previous experience.

*Award **[1]** for each of the features stated above, up to **[2]**.*

(ii) Outline **one** benefit of using deep learning. [2]

Answers may include:
- Data labelling is not necessary, so it saves time
- …because the algorithm will learn for itself

- May allow for hidden patterns / correlations to be found in the data / able to perform thousands of routines, repetitive tasks within a relatively shorter period of time compared / subjective defects which are hard to train like minor product labeling errors etc. can be detected
- …because the AI is able to learn for itself and adapt more quickly than a team of analysts can

- Can use data from a range of formats
- …because the algorithms are able to label the data accordingly

- Maximum utilization of unstructured data / uses different data formats to train deep learning algorithms and still obtain insights.

- Ability to deliver high-quality results.

*Award **[1]** for either defining a benefit of deep learning and **[1]** for a development of that benefit, up to **[2]**.*

(iii) Identify **two** features of an algorithm. [2]

Answers may include:
- A set of rules to complete a task
- Rules that can be followed by a computer
- Finite number of steps
- Each step takes a finite amount of time
- Has 0 or more defined inputs
- Has 1 or more defined outputs

*Award **[1]** for each feature identified, up to **[2]**.*

(b) *TSE Global* needs to decide whether to use black-box **or** white-box testing.

Analyse these two options. [6]

Answers may include:

Advantages of white-box testing
- It is internal software testing and can find internal errors.
- This type of testing of software is started after detail design document / early in the SDLC.
- Applicable to the lower levels of software testing.
- It is suitable for algorithm testing.
- Data domains along with inner or internal boundaries can be better tested. Focuses on the code rather than the user.
- Easier to automate as the testing is carried out at a modular scale (rather than the whole product).

Advantages of black-box testing
- No knowledge of implementation is needed.
- No knowledge of the internal structure of the code is required as it only tests the operation of the system.
- It is less time consuming.
- It is cheaper.
- Can be done by trial and error ways and methods.
- Focuses on the end user.

Marks	***Level descriptor***
[0]	*No knowledge or understanding of ITGS issues and concepts. No use of appropriate ITGS terminology*
[1–2]	*A limited response that indicates very little understanding of the topic or the reason is not clear. Uses little or no appropriate ITGS terminology. No reference is made to the scenario in the stimulus material. The response is theoretical.*
[3–4]	*A description, unbalanced or partial analysis of white box and black box testing. There is some use of appropriate ITGS terminology in the response.*
[5–6]	*A balanced and thorough analysis of white box and black box testing. Explicit and relevant references are made to the scenario in the stimulus material. There is appropriate ITGS terminology throughout the response.*

(c) Discuss whether *TSE Global* should incorporate ethical design at each stage of software development. [8]

Answers may include:

Advantages of ethical design being used at each stage of the software development process:

- The software design is predicated on the principal of not causing harm / being beneficial in use.
- Transparency which may lead to increased trust in the software.
- May be able to identify algorithmic bias as the steps involved in testing may be discreet enough for this to be determined.
- Can identify errors within the system at each stage (so they do not perpetuate themselves in subsequent stages).
- The increased focus on ethical design may lead to an understanding of how (ethical) hackers may be trying to gain unauthorized access to an organization's network.

Disadvantages of ethical design being used at each stage of the software development process:

- Involving with a range of stakeholders at each stage will lead to an increase in development time (which may have commercial ramifications in a commercial environment).
- The increased involvement of stakeholders may lead to increased costs in the development of the software, and this may make it not viable financially.
- Increased transparency may lead to compromising of sensitive company information.
- Moving towards the ethical development of software may lead to increased training costs for staff and changing the culture of the company developing the software.

In part (c) of this question it is expected there will be a balance in the ITGS terminology between IT technical terminology and the terminology related to social and ethical impacts.

Please see generic markband on page 22.

6. Autonomous underwater robots

(a) (i) Identify **two** sensors required by the autonomous underwater robots. [2]

Answers may include:
- Pressure sensor
- Altimeter
- Tilt sensor
- Gyro
- Magnetic compass
- Navigation acoustic sensor
- Camera (vison sensor)
- Proximity sensor
- Temperature sensor
- Infra-red sensor
- pH sensor.

*Award **[1]** for each sensor identified, up to **[2]**.*

(ii) Identify **two** items of data that could be collected by the autonomous underwater robots. [2]

Answers may include:
- Water temperature
- Salinity / pH
- Coral hardness
- Quantity of nutrients.

*Award **[1]** for each of the items stated above, up to **[2]**.*

(iii) Identify **two** advantages of fuzzy logic compared to inference rules. [2]

Answers may include:
- Fuzzy logic has variable processing, which allows for multiple non-binary values to be processed with the same variable.
- Fuzzy logic attempts to solve problems with an open range of data that makes it possible to obtain an array of conclusions.
- Fuzzy logic considers all available information and making the best possible decision given the input.
- It is useful in complex situations where judgement and reasoning are involved.

*Award **[1]** for each advantage of using fuzzy logic compared to inference rules, up to **[2]**.*

(b) (i) Explain **one** reason why an agile project development (scrum) methodology would be used for the development of the underwater robots. [2]

Answers may include:
- The area underwater robotics is constantly evolving – the agile method allows the developers to constantly make changes.
- Allows the client to be involved throughout the process.
- More adaptable than using a waterfall project development methodology.
- Able to eliminate / change approaches that do not work.
- May lead to greater specialization during the development leading to better outcomes.

*Award **[1]** for the identification of a reason why an agile project development methodology and **[1]** for the explanation of that reason, up to **[2]**.*

(ii) Explain **two** reasons why prototyping would be used in the development of the autonomous underwater robots. [4]

Answers may include:
- Show the client what to expect
- Reduce revising the project, eliminate approaches that don't work

- Test the design
- Allows clients to make changes, get feedback to help improve the product

- Gives more information about the potential costs
- Which allows the developer to make an informed decision about whether to develop the final product

*Award **[1]** for the identification of a reason why prototyping would be used and **[1]** for the explanation of that reason, up to **[2]**.*

*Mark as **[2] + [2]**.*

(c) Discuss whether autonomous underwater robots instead of humans should be used to monitor the condition of coral reefs and make decisions, such as whether to restore them. [8]

Answers may include:

Advantages of autonomous underwater robots over humans

- Robots do not make decision based on emotion – preservation of coral reefs is an emotive topic and humans could be biased.
- Robots do not get tired or need time off - work can proceed faster – time is running out with climate change affecting reefs.
- A number of autonomous robots working together would be able to monitor a larger area of coral than a team of divers.
- The increased information being gathered by the autonomous robots would allow more detailed analysis / modelling of the coral reef.
- Decision making is likely to be consistent between swarms of autonomous robots.
- The autonomous robots may be linked to AI to process this information and better decision making linked to the preservation / sustainability of the coral reef being made.
- Robots can reach places that are too dangerous.
- Robots can perform repetitive tasks.
- Robots can collect more data than humans.

Disadvantages of autonomous robots over humans

- The initial cost of using the autonomous robots may be greater than using a team of divers.
- The autonomous robots may need to be trained using data sets of existing coral reefs.
- Are there likely to be enough datasets that can be used for this purpose / different coral reefs may have subtle differences in their ecosystems (water temp / pH) which may impact on the decision making.
- Can the autonomous robots be programmed to understand the human emotions that may mean that areas of reef that hold emotional attachment may be left to die.
- Can the autonomous robot be trusted to make the right decision?

In part (c) of this question it is expected there will be a balance in the ITGS terminology between IT technical terminology and the terminology related to social and ethical impacts.

Please see generic markband on page 22.

SL and HL paper 1 part (c) and HL paper 3 question 3 markband

Marks	***Level descriptor***
No marks	• *A response with no knowledge or understanding of the relevant ITGS issues and concepts.* • *A response that includes no appropriate ITGS terminology.*
Basic 1–2 marks	• *A response with minimal knowledge and understanding of the relevant ITGS issues and concepts.* • *A response that includes minimal use of appropriate ITGS terminology.* • *A response that has no evidence of judgments and/or conclusions.* • *No reference is made to the scenario in the stimulus material in the response.* • *The response may be no more than a list.*
Adequate 3–4 marks	• *A descriptive response with limited knowledge and/or understanding of the relevant ITGS issues and/or concepts.* • *A response that includes limited use of appropriate ITGS terminology.* • *A response that has evidence of conclusions and/or judgments that are no more than unsubstantiated statements. The analysis underpinning them may also be partial or unbalanced.* • *Implicit references are made to the scenario in the stimulus material in the response.*
Competent 5–6 marks	• *A response with knowledge and understanding of the relevant ITGS issues and/or concepts.* • *A response that uses ITGS terminology appropriately in places.* • *A response that includes conclusions and/or judgments that have limited support and are underpinned by a balanced analysis.* • *Explicit references to the scenario in the stimulus material are made at places in the response.*
Proficient 7–8 marks	• *A response with a detailed knowledge and understanding of the relevant ITGS issues and/or concepts.* • *A response that uses ITGS terminology appropriately throughout.* • *A response that includes conclusions and/or judgments that are well supported and underpinned by a balanced analysis.* • *Explicit references are made appropriately to the scenario in the stimulus material throughout the response.*