

**Computer science
Higher level
Paper 1****Mock examination — Set 1**

2 hours

Candidate session number

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Instructions for candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- A clean copy of the **computer science case study** is required for this examination paper.
- Read the case study carefully.
- Section A: answer all the questions.
- Section B: answer the question.
- Answers must be written within the answer boxes provided.
- The maximum mark for this examination paper is **[80 marks]**.

Section A

Answer **all** questions from this section. Answers must be written within the answer boxes provided.

1. Quillfeather Studios is an animation and visual-effects studio whose artists work on high-performance workstations.

(a) State **one** type of primary memory, other than cache memory.

[1]

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(b) Outline what happens when a cache miss occurs.

[2]

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A warning light, Q , on the studio's motion-capture stage is controlled by a logic circuit with three inputs, A , B and C . The circuit is represented by the Boolean expression:

$$Q = (A \text{ NAND } B) \text{ AND } (B \text{ XOR } C)$$

(c) Construct a logic diagram for this Boolean expression.

[3]

(This question continues on the following page)

(Question 1 continued)

The studio stores each frame of a film as an uncompressed bitmap image of 2048×1080 pixels, with a colour depth of 24 bits.

- (d) Calculate the size of one frame in bytes. [1]

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The render farm's cooling system reads a temperature sensor every two seconds.

- (e) Outline **one** reason why polling, rather than interrupts, is suitable for reading this sensor. [2]

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For live-action scenes, the studio films actors with a camera mounted on a robotic arm. The arm must repeat exactly the same movement for every take, so that computer-generated effects can be lined up with the filmed footage.

- (f) Explain how a closed-loop control system enables the robotic arm to repeat the programmed movement accurately. [4]

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2. Quillfeather Studios has a local area network (LAN) that connects its artists' workstations to its servers.

The studio's building has four floors. On each floor, the workstations are connected to a switch in a star topology. The four floor switches are connected to each other in a mesh topology.

- (a) List **two** advantages of this hybrid topology for the studio. [2]

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Animators send finished frame files from their workstations to a file server.

- (b) Outline why the transmission control protocol (TCP), rather than the user datagram protocol (UDP), is used to transfer these files. [2]

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Clients view unfinished scenes on the studio's review website. When a client's browser connects to the website, the website's digital certificate and asymmetric encryption are used so that the browser and the website can share a symmetric session key.

- (c) Describe how the symmetric session key is shared securely. [3]

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(Question 2 continued)

When a new workstation is connected to the LAN, it receives its network settings from a dynamic host configuration protocol (DHCP) server.

- (d) Outline how the DHCP server provides the new workstation with an IP address. [2]

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Animators sometimes connect their laptops to public wireless networks when they travel to film festivals.

- (e) Describe how a man-in-the-middle (MitM) attack could be carried out against an animator who is using a public wireless network. [2]

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The studio's network also contains several routers that link the floor switches to its servers and render farm. There is more than one possible path between most pairs of routers, and the routers use dynamic routing.

- (f) Explain how dynamic routing allows data to keep reaching its destination when a link between two routers fails. [3]

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3. Quillfeather Studios uses a relational database to manage the production of its animated films.

The tables ANIMATOR and SHOT are extracts from this database. Each shot is assigned to one animator. The DueDate field represents the date by which the shot must be finished.

The ANIMATOR table:

AnimatorID	FirstName	LastName	Specialism	DayRate
A01	Priya	Raman	Character	420.00
A02	Tomás	Ferreira	Effects	465.50
A03	Hana	Sato	Character	398.75
A04	Kwame	Mensah	Lighting	410.00
A05	Lucía	Ortega	Effects	452.25

The SHOT table:

ShotID	Film	AnimatorID	Frames	DueDate	Status
S101	Lantern Tide	A01	96	2027-02-26	Approved
S102	Lantern Tide	A03	144	2027-03-05	In progress
S103	Lantern Tide	A03	72	2027-02-19	Approved
S104	The Copper Kite	A02	210	2027-03-19	In progress
S105	The Copper Kite	A01	120	2027-04-02	Not started
S106	The Copper Kite	A03	168	2027-03-31	Not started
S107	Lantern Tide	A04	60	2027-03-12	Approved

- (a) Construct an SQL query to list the ShotID and DueDate of each shot that is due in March 2027, together with the LastName of the animator assigned to it.

The results should be listed with the earliest due date first.

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(Question 3 continued)

Animator A03 is moving to a different project. All of A03's shots that have not been approved will be reassigned to animator A05.

- (b) Construct an SQL statement to make this change. [2]

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- (c) Construct an SQL query to list the LastName of each animator, together with the total number of frames in the shots assigned to that animator.

Only animators with a total of more than 200 frames should be listed. [3]

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The studio stores data about all its past productions in a data warehouse. For every shot, the warehouse records each production stage that the shot passed through, in order, with the date of each stage.

- (d) Describe how sequential pattern discovery could help the studio to deliver future shots on time. [3]

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(Question 3 continued)

The studio wants to extend the database to store feedback from its directors. The following rules apply:

- Each item of feedback is about one shot and is written by one director.
- A director can write many items of feedback, but some directors have not written any feedback yet.
- A shot can receive many items of feedback, but some shots have not received any feedback yet.

(e) Construct an entity relationship diagram (ERD) for the entities SHOT, DIRECTOR and FEEDBACK, showing cardinality and modality.

[3]

4. Quillfeather Studios uses machine learning to help plan and manage its productions.

The studio uses a decision tree to classify each new shot as “simple”, “standard” or “complex”. The decision tree was trained on data about 3000 previous shots, each labelled by a producer with its correct class. It uses features such as the number of characters, the number of frames and whether the shot contains water or hair effects.

- (a) State the type of machine learning used to train this decision tree. [1]

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- (b) Outline how the decision tree classifies a new shot. [2]

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The decision tree correctly classifies 99% of the shots in its training data, but only 68% of new shots.

- (c) Describe what these results suggest about the decision tree model. [2]

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The studio uses a genetic algorithm to decide the order in which render jobs are sent to its render farm. Each candidate solution is one possible order of the jobs.

- (d) Outline the role of the fitness function in this genetic algorithm. [2]

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(Question 4 continued)

The studio uses linear regression to predict how long a shot will take to render. The model was trained on data from 400 previous shots, each between 20 and 240 frames long:

$$\text{render time (hours)} = 0.35 \times \text{number of frames} + 4$$

The r^2 value for the model is 0.52.

- (e) Explain why the predicted render time for a new shot of 600 frames may be unreliable. [3]

The studio has introduced a machine learning system that monitors how animators use their workstations. It records data such as active working time, the number of edits made each hour and how long each shot takes. The system predicts which animators are likely to miss deadlines, and managers use these predictions when allocating work and deciding on bonuses.

Some animators say that the system cannot measure creative work fairly, and that they did not agree to be monitored in this way. The studio says that the system helps it to deliver films on time and to identify animators who need support.

- (f) Discuss whether the studio should continue to use this system. [5]

Section B

Answer the following question, which refers to the case study. Answers must be written within the answer boxes provided.

5. Visionary Studios plans to train a diffusion model to generate images for advertising campaigns, concept art and digital media.

Visionary Studios' training dataset contains far more images of young, light-skinned people than of other groups.

- (a) (i) Outline **one** consequence of this for the faces generated for its advertising campaigns.

[2]

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Visionary Studios' diffusion model uses a convolutional neural network (CNN) as its denoiser.

- (ii) Outline the role of the CNN in generating an image from random noise.

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(Question 5 continued)

Visionary Studios' prototype diffusion model applies its denoiser 1000 times to generate each image. Producing one high-resolution image takes several minutes.

- (b) Outline **two** ways in which Visionary Studios could address the computational demands of generating images with this model.

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Visionary Studios trained a GAN to generate faces for a cosmetics advertising campaign. The generator produced almost identical faces, whatever noise vector it was given.

- (c) Describe how the adversarial dynamic between the generator and the discriminator can lead to this problem.

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