

Computer science**Higher level****Paper 1****Mock examination — Set 2**

Candidate session number

2 hours

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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. Ambergate Creative is a digital advertising agency. Its designers create video adverts, banner adverts and brand graphics on desktop computers.

- (a) State **one** function of the control unit (CU) in a central processing unit (CPU). [1]

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The agency's web pages specify each colour with six hexadecimal digits. The first two digits give the intensity of red, the next two give the intensity of green and the last two give the intensity of blue. Each intensity is a decimal value from 0 to 255.

The agency's brand colour is:

3CB4E6

- (b) (i) State the decimal value of the green intensity of the brand colour. [1]

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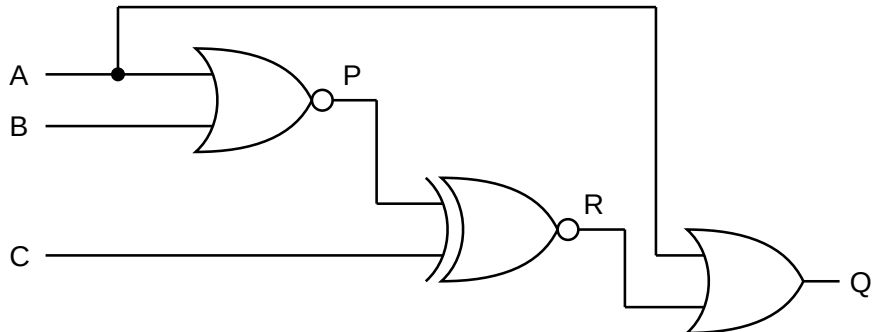
- (ii) A designer changes only the red intensity of the brand colour, to 200 in decimal. State the six hexadecimal digits for the new colour. [1]

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(Question 1 continued)

A digital billboard that the agency manages is controlled by the following logic circuit. The circuit has three inputs, A, B and C, and one output, Q. P and R are the outputs of two of the gates.



(c) Construct the truth table for this circuit.

[3]

A	B	C	P	R	Q

The designers use graphics tablets with several different drawing applications.

(d) Describe how the operating system allows each drawing application to work with graphics tablets made by different manufacturers.

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(Question 1 continued)

Each core of the CPU in the designers' computers uses a four-stage pipeline: fetch, decode, execute and write-back. Each stage takes one clock cycle.

- (e) Calculate the number of clock cycles that one core needs to complete a sequence of 10 instructions, both without pipelining and with pipelining.

Assume that no instruction has to wait for another instruction to finish.

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When the video-editing software applies a colour effect to every frame of a video advert, the work is shared between the CPU and the graphics processing unit (GPU).

- (f) Explain how the work is divided between the CPU and the GPU so that the effect is applied quickly.

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2. Ambergate Creative's office has a local area network (LAN) that connects its staff computers, a file server and a web server. The LAN is connected to the internet through a router.

- (a) State the layer of the TCP/IP model at which a router operates. [1]

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All the agency's computers share the router's single connection to the internet. Designers often upload large video files to clients while other staff are browsing the web and sending emails.

- (b) Explain how packet switching allows all these transfers to use the connection at the same time. [3]

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The agency manages 60 digital billboards around the country. At present, each billboard downloads every new video advert, a file of about 4 GB, from the agency's web server. The agency is considering a peer-to-peer system instead, in which each billboard that has received part of a new advert also sends that part to other billboards.

- (c) Explain why the peer-to-peer system could deliver a new advert to all the billboards more quickly than the current client-server system. [3]

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(Question 2 continued)

Visitors to some of the campaign web pages can post comments, which are then displayed to all other visitors.

- (d) Describe how a cross-site scripting (XSS) attack could be carried out using the comment feature. [2]

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- (e) Outline how a content security policy (CSP) for the campaign web pages would reduce the risk from this type of attack. [2]

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The web server holds the campaign web pages that the agency creates for its clients, so it must be reachable from the internet. The agency places the web server in a separate network segment from the staff computers and the file server. A firewall controls the traffic between the segments, and allows web traffic from the internet to reach only the web server.

- (f) Explain why the firewall should also block connections from the web server to the staff computers and the file server. [3]

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3. Ambergate Creative uses a relational database to manage its advertising campaigns.

The tables CLIENT and CAMPAIGN are extracts from the database. Each campaign is for one client. The Channel field shows where the campaign's adverts appear, and the Budget field is the campaign's budget in euros.

The CLIENT table:

ClientID	ClientName	Sector	City
C01	Harbour Bakery	Food	Bristol
C02	Velo Verde Cycles	Retail	Lisbon
C03	Ferncliff Savings	Finance	Leeds
C04	Kiko Toys	Retail	Osaka
C05	Pinecrest Hotels	Travel	Cork

The CAMPAIGN table:

CampaignID	ClientID	Title	Channel	Budget
P101	C02	Ride to Work	Display	18000
P102	C04	Toy Box Live	Video	42500
P103	C01	Fresh Every Morning	Display	9500
P104	C02	City Commuter	Video	27000
P105	C03	Save Smart	Video	55000
P106	C04	Summer Play	Social	12000
P107	C02	Trail Kit Sale	Video	31500

The database administrator allows the agency's account managers to use data manipulation language (DML) statements, but not data definition language (DDL) statements. An account manager tries to run these two statements:

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ALTER TABLE CAMPAIGN ADD StartDate DATE;  
UPDATE CAMPAIGN SET Budget = 10000 WHERE CampaignID = 'P103';
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- (a) Outline why only one of these statements is carried out.

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(Question 3 continued)

- (b) Construct an SQL query to list the Title and Budget of every campaign that is for a client in the Retail sector and is not shown on the Social channel, together with the ClientName of that client.

The campaigns should be listed with the largest budget first.

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The account managers use a virtual view, CAMPAIGN_LIST, which shows every campaign's Title, Channel and Budget together with its ClientName.

- (c) Outline **one** advantage and **one** disadvantage of changing CAMPAIGN_LIST to a materialized view.

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Two account managers each increase the budget of campaign P107 by 5000 euros at the same time. Each manager's application reads the budget, adds 5000 and writes the new value back, as one transaction.

- (d) Describe how the isolation property ensures that the final budget of P107 is 41 500 euros.

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(Question 3 continued)

The agency also hires freelance photographers and stylists for photo shoots. The bookings are currently recorded in a single table, SHOOT_BOOKINGS. The following rules apply:

- Each freelancer has a unique FreelancerID, each shoot has a unique ShootID and each studio has a unique StudioID.
- Each shoot takes place on one date in one studio.
- Several freelancers can work at the same shoot, and a freelancer can work at many shoots.
- The fee is agreed separately for each freelancer at each shoot.

An extract of SHOOT_BOOKINGS:

FreelancerID	FreelancerName	ShootID	ShootDate	StudioID	StudioName	Fee
F12	Ana Ribeiro	SH31	2027-02-08	ST1	Quay Studio	650
F17	Tom Okafor	SH31	2027-02-08	ST1	Quay Studio	400
F12	Ana Ribeiro	SH32	2027-02-15	ST2	Loft Nine	700
F20	Mei Lin	SH32	2027-02-15	ST2	Loft Nine	520
F17	Tom Okafor	SH33	2027-03-01	ST1	Quay Studio	450

SHOOT_BOOKINGS can be represented by the following notation:

SHOOT_BOOKINGS (FreelancerID, FreelancerName, ShootID, ShootDate, StudioID, StudioName, Fee)

- (e) Construct the database in third normal form (3NF) for the data in SHOOT_BOOKINGS.

Identify the primary key and any foreign keys in each table.

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4. Ambergate Creative uses machine learning to plan and target its clients' online adverts.

The agency uses reinforcement learning to decide which of four versions of a banner advert to show each time a client's web page is loaded. The agent receives a reward of 1 if the visitor clicks on the advert, and a reward of 0 if they do not.

- (a) (i) State the term for the rule that the agent follows to choose an action in each state. [1]

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- (ii) Describe how the agent uses the rewards to improve its choice of version over time. [2]

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The agency analysed 40 000 online orders placed with a client that sells camping equipment. 2000 of the orders included a tent, and 1500 of these orders also included a sleeping bag. Altogether, 5000 of the orders included a sleeping bag.

- (b) (i) Calculate the confidence of the association rule {tent} → {sleeping bag}. [1]

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- (ii) The lift of this rule is 6. Outline what this value shows about the sales of tents and sleeping bags. [2]

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(Question 4 continued)

The agency uses clustering to divide the visitors to a client's website into groups, so that each group can be shown different adverts. Each visitor is described by 300 features, such as the pages viewed, the time spent on each page and the products clicked.

- (c) Outline why reducing the number of features before clustering would improve the groups that are found.

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Before an advert is published, a convolutional neural network (CNN) checks each image in the advert to find out whether it contains the client's logo.

- (d) Describe how the layers of the CNN build up the features that allow it to recognize the logo wherever it appears in an image.

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(e) Discuss whether the agency should accept this campaign.

[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 is comparing different generative AI models for the image generation system that it will use in client projects.

Visionary Studios' existing unconditional model was trained on millions of photographs collected from the internet. To avoid training its next model directly on these photographs, the studio plans to use the existing model to generate a synthetic dataset.

- (a) (i) Outline **one** reason why using this synthetic dataset may not remove the intellectual property or bias concerns about the training data. [2]

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Visionary Studios' diffusion model can be set to use different numbers of denoising steps. Starting from the same random noise, an image generated in 50 steps takes about five times as long to produce as an image generated in 10 steps, but it shows finer detail.

- (ii) Outline why using more denoising steps increases both the time taken and the detail in the image. [2]

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Visionary Studios' clients often ask for several variations of a design that they have approved. Some clients also ask for evidence of exactly how each final image was produced.

- (b) (i) Outline how a VAE could help Visionary Studios to produce the variations. [2]

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(Question 5 continued)

- (ii) Outline how a flow-based model could help Visionary Studios to provide evidence of exactly how each final image was produced. [2]

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Early in the training of a GAN for a client's campaign, Visionary Studios' discriminator learned to classify every generated image as fake with almost complete certainty. After this, the generator's images stopped improving.

- (c) (i) Describe how this imbalance prevented the generator from improving. [2]

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- (ii) Outline **one** way in which Visionary Studios could restore the balance between the two networks. [2]

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