National Qualifications 2026

X816/77/11 Computing Science

WEDNESDAY, 20 MAY
9:00 AM – 11:00 AM

Total marks — 55

SECTION 1 — Software design and development — 35 marks

Attempt ALL questions.

Attempt EITHER Section 2 OR Section 3

SECTION 2 — Database design and development — 20 marks

SECTION 3 — Web design and development — 20 marks

You may use a calculator.

Write your answers clearly in the answer booklet provided. In the answer booklet you must clearly identify the question number you are attempting.

Use **blue or black** ink.

You must leave your answer booklet on your desk; if you do not, you could lose all the marks for this paper.

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MARKS

SECTION 1 — SOFTWARE DESIGN AND DEVELOPMENT — 35 marks

Attempt ALL questions

1. The contents of the 1-D array [12, 14, 2, 5, 7, 19, 15, 5, 7] are to be sorted in ascending order using the bubble sort algorithm.

   (a) Describe one difference between an array and a linked list. 1

   (b) The comparisons at steps 1, 2, 3 and 4 in the first pass of this bubble sort are shown below.

Step	Comparison
1	Compare 12 and 14 → no swap → [12, 14, 2, 5, 7, 19, 15, 5, 7]
2	Compare 14 and 2 → swap → [12, 2, 14, 5, 7, 19, 15, 5, 7]
3	Compare 14 and 5 → swap → [12, 2, 5, 14, 7, 19, 15, 5, 7]
4	Compare 14 and 7 → swap → [12, 2, 5, 7, 14, 19, 15, 5, 7]
5	
6	
7	
8	

   Describe the comparisons that take place at steps 5, 6, 7 and 8 in the first pass of the bubble sort algorithm.

   Your description should include the level of detail provided for steps 1–4. 2

MARKS

2. A cryptocurrency exchange is developing a new app to run on mobile phones.

(a) Explain why economic and technical feasibility must be considered before the app is developed. 2

(b) The developers create a persona and test cases to use during final testing.

Persona

Description

Stephen is a 26-year-old web developer. He has multiple accounts on crypto exchanges and is interested in frequent trading transactions.

Technical skills

Stephen is an experienced user of mobile phones, laptops and desktop computers.

Accessibility

Stephen uses the built-in screen reader of his mobile phone to read aloud everything that is on the screen. He also uses the speech-to-text functionality on his phone to enter text by speaking instead of typing.

Test cases

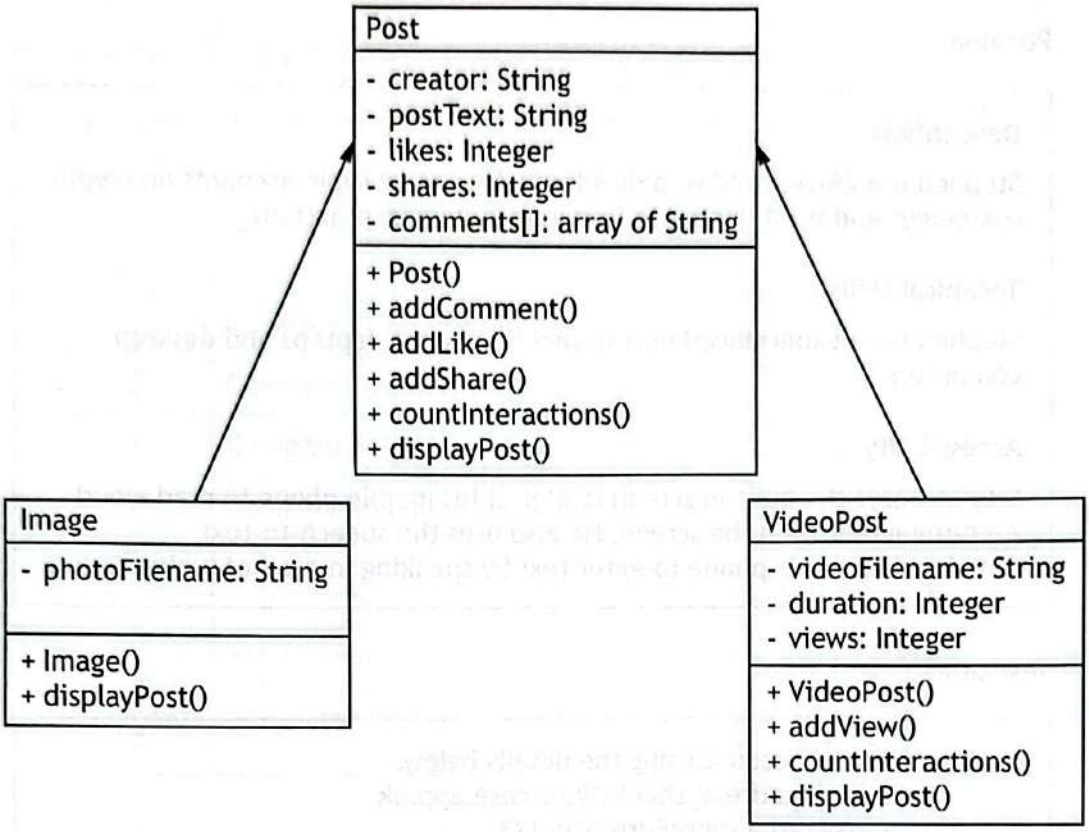
1. Set up a new account using the details below.
   e-mail address: sbanks@testcase.app.uk
   password: Crypto£urrency$123
2. Check the account wallet to see the account balance and live prices for the currency.
3. Buy 15 units of the currency and check that the account wallet updates correctly.

Describe how the persona and test cases would be used in final testing. 2

[Turn over

3. A programmer is developing a social media app using object-oriented programming. The app will allow a creator to post text, videos and images and allow other users to interact with the posts through comments, likes, shares and video views. Posts with more interactions appear in more user feeds.

A simplified UML class diagram for the program is shown below.



Some of the code used to implement the social media app is shown below.

```
CLASS Post IS {STRING creator, STRING postText, INTEGER likes,
INTEGER shares, ARRAY OF STRING comments}

METHODS
    CONSTRUCTOR (STRING creator, STRING postText)
        DECLARE THIS.creator INITIALLY creator
        DECLARE THIS.postText INITIALLY postText
        DECLARE THIS.likes INITIALLY 0
        DECLARE THIS.shares INITIALLY 0
        DECLARE THIS.comments INITIALLY []
    END CONSTRUCTOR

    PROCEDURE addLike()
        SET THIS.likes TO THIS.likes + 1
    END PROCEDURE

    PROCEDURE addShare()
        SET THIS.shares TO THIS.shares + 1
    END PROCEDURE
```

MARKS

3. (continued)

```
    FUNCTION countInteractions() RETURNS INTEGER
        DECLARE interactions INITIALLY 0
        SET interactions TO length(THIS.comments)+ THIS.likes +
            THIS.shares
        RETURN interactions
    END FUNCTION
    ...
    PROCEDURE displayPost()
        SEND "Post by " & THIS.creator TO DISPLAY
        SEND "Text: " & THIS.postText TO DISPLAY
        SEND "Likes: " & THIS.likes TO DISPLAY
        SEND "Shares: " & THIS.shares TO DISPLAY
        SEND "Comments: " TO DISPLAY
        IF length(THIS.comments) = 0 THEN
            SEND "No user comments yet." TO DISPLAY
        ELSE
            FOR EACH comment FROM THIS.comments DO
                SEND comment TO DISPLAY
            END FOR
        END IF
    END PROCEDURE
END CLASS
```

(a) The main program contains the following code.

```
Line 1    DECLARE post1 INITIALLY Post('Ally', 'Loving this
          beautiful day at the beach!')
Line 2    <create an array of objects called posts>
Line 3    DECLARE posts AS ARRAY OF Post INITIALLY [] * 5
Line 4    SET posts[0] TO post1
Line 5    posts[0].addLike()
Line 6    posts[0].addShare()
Line 7    posts[0].addLike()
Line 8    posts[0].addShare()
Line 9    posts[0].addLike()
Line 10   posts[0].displayPost()
```

(i) Using appropriate object-oriented terminology, describe the effect of the code at line 1. 2

(ii) Write the output produced by line 10. 3

[Turn over

3. (continued)

(b) The code to implement video uploads is shown below.

```
CLASS VideoPost INHERITS Post WITH (STRING videoFilename,
INTEGER duration, INTEGER views)

METHODS
    CONSTRUCTOR (STRING creator, STRING postText, STRING
    videoFilename, INTEGER duration)
      DECLARE THIS.videoFilename INITIALLY videoFilename
      DECLARE THIS.duration INITIALLY duration
      DECLARE THIS.views INITIALLY 0
      DECLARE THIS.creator INITIALLY creator
      DECLARE THIS.postText INITIALLY postText
      DECLARE THIS.likes INITIALLY 0
      DECLARE THIS.shares INITIALLY 0
      DECLARE THIS.comments INITIALLY []
    END CONSTRUCTOR

    PROCEDURE addView()
      SET THIS.views TO THIS.views + 1
    END PROCEDURE

    OVERRIDE PROCEDURE displayPost()
      SEND "Video posted by " & THIS.creator TO DISPLAY
      SEND "Text: " & THIS.postText TO DISPLAY
      <code used to display video content>
      SEND "Duration: " & THIS.duration & "s" TO DISPLAY
      SEND "Views: " & THIS.views TO DISPLAY
      SEND "Likes: " & THIS.likes TO DISPLAY
      SEND "Shares: " & THIS.shares TO DISPLAY
      SEND "Comments: " TO DISPLAY
      IF length(THIS.comments) = 0 THEN
         SEND "No user comments yet." TO DISPLAY
      ELSE
         FOR EACH comment FROM THIS.comments DO
            SEND comment TO DISPLAY
         END FOR
      END IF
    END PROCEDURE
END CLASS
```

3. (b) (continued)

(i) The `countInteractions()` method inherited from the `Post` class does not take into account the number of times a video has been viewed.

Using a programming language of your choice, write the `countInteractions()` method for the `VideoPost` class. 1

(ii) The programmer uses the code below to create a video post and add it in the `posts` array of objects from part (a).

```
Line 1   DECLARE post2 INITIALLY VideoPost('Charlie',
         'Watch this amazing trick!', 'myVideo.mp4', 30)
Line 2   SET posts[1] to post2
Line 3   posts[1].addView()
```

Explain why the code in line 3 would generate an error. 2

[Turn over

3. (continued) MARKS

(c) The programmer uses the insertion sort algorithm to sort the contents of the array of objects `posts` in descending order of the number of user interactions.

This will allow the most engaging content to be displayed at the top of users' feeds.

The design for the insertion sort algorithm used is shown below.

```
1. start fixed loop i from 1 to (length of posts array) - 1
2.       set temp object = posts(i)
3.       set j = i
4.       while j > 0 and (number of interactions for posts(j-1) < number of
         interactions for temp object)
5.           set posts(j) = posts(j-1)
6.           set j = j - 1
7.       end loop
8.       set posts(j) = temp object
9.  end loop
```

Data associated with the five objects of the `posts` array is shown below.

Index	`posts[index].creator`	`posts[index].countInteractions()`
0	Ally	834
1	Charlie	923
2	Jude	1228
3	Sophie	846
4	Priya	791

The comparisons made when the insertion sort is applied to the array of objects `posts` to sort contents in descending order of number of interactions are shown in the table below.

State the missing content of cells A, B and C. 3

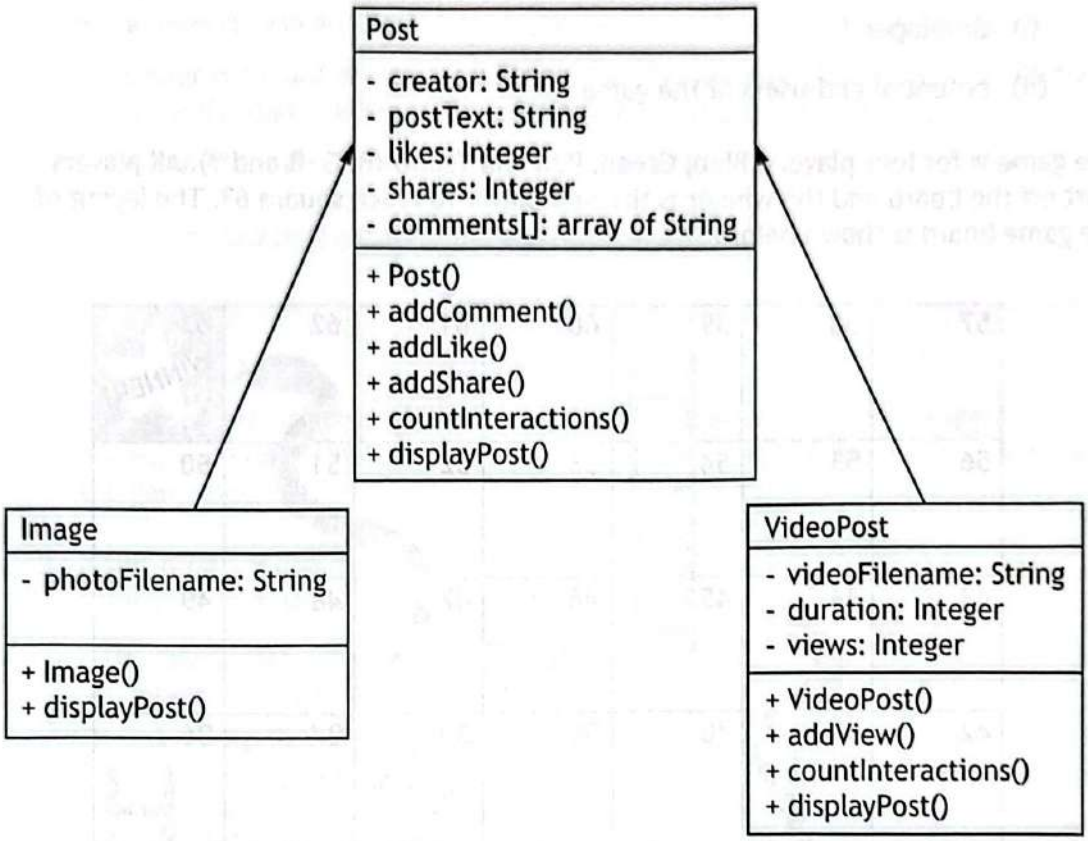
Iteration	Comparison	`temp.creator`	Move	Insertion
1	834 < 923	Charlie	Object at index 0 copied to index 1	Temp object inserted at index 0
2	A	Jude	Object at index 1 copied to index 2	
2	923 < 1228	Jude	B	Temp object inserted at index 0
3	834 < 846	Sophie	Object at index 2 copied to index 3	
3	923 < 846	Sophie	No move needed	C
4	834 < 791	Pryia	No move needed	Temp object inserted at index 4

MARKS

3. (continued)

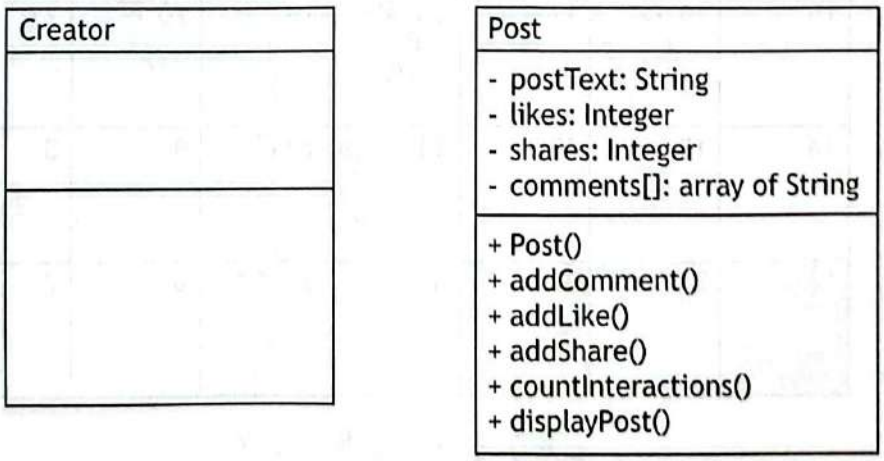
(d) As the social media app becomes more popular, the programmer realises that there is a need for a new `Creator` class to allow creators to make an account.

The original UML class diagram is shown below.



The programmer would like to store a creator's name, date of birth, e-mail address and references to each post that the creator makes. A creator should be able to add, edit and delete posts.

Copy and complete the partially updated UML class diagram below for the new `Creator` class. 2



MARKS

4. A developer has been employed to create an online game in the style of 'Snakes and Ladders'.

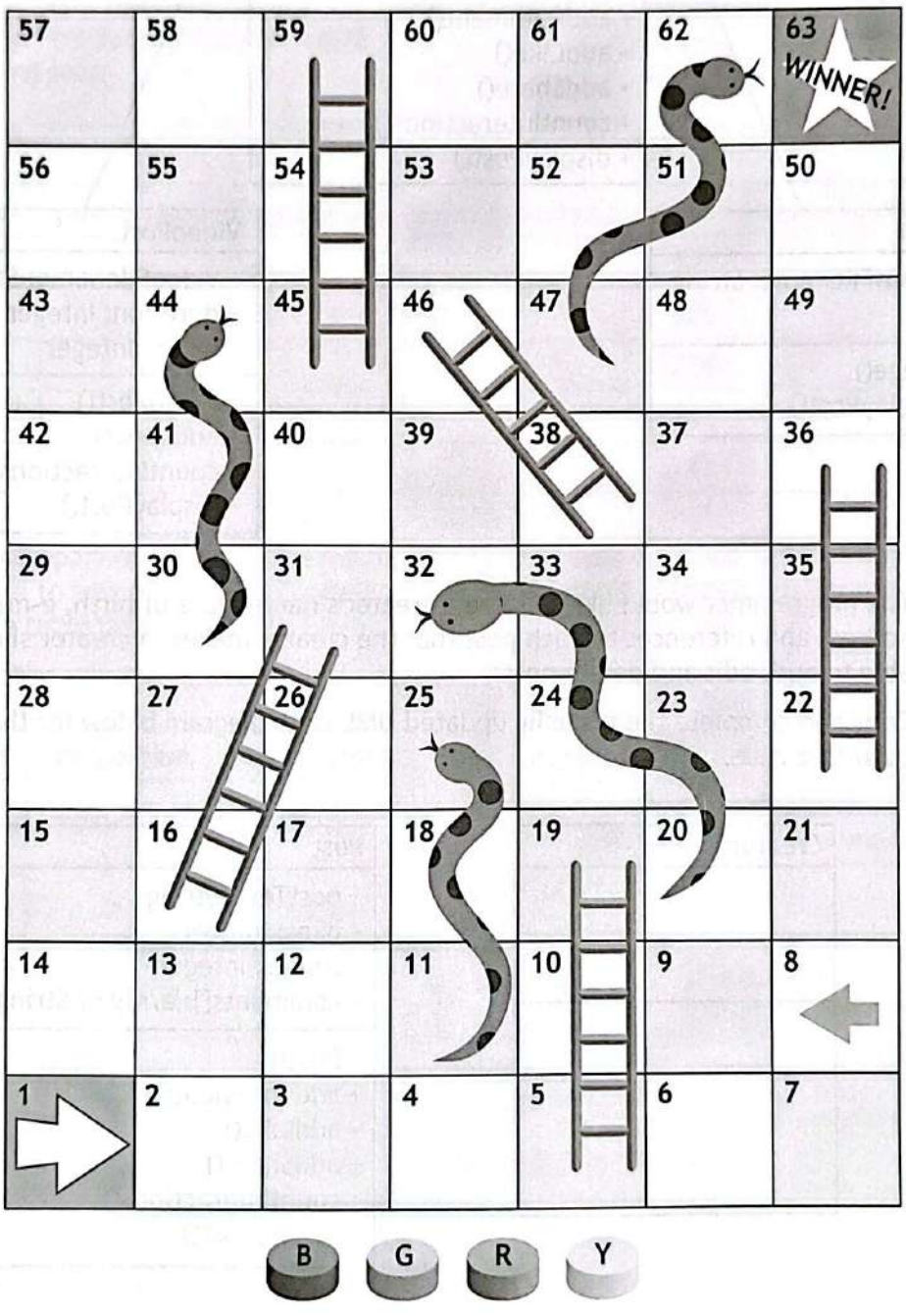
(a) During the analysis, the developer creates a user survey that will be completed by potential end-users.

Describe one benefit of user surveys for the:

(i) developer 1

(ii) potential end-users of the game. 1

The game is for four players: Blue, Green, Red and Yellow (B, G, R and Y). All players start off the board and the winner is the first player to reach square 63. The layout of the game board is shown below.



Players start off the board

4. (continued) MARKS

(b) The developer uses a record structure to store details of each square with a 2-D array of records being used to reference details of all 63 squares on the game board.

The record structure will store three values:

- a numeric value from 1–63 to indicate the position of a single square
- either the word 'empty' to indicate that the square has no playing piece on it, or the name of the colour of the playing piece occupying the square
- a numeric value from 0–63 to act as a pointer.

The code used to implement the record structure is shown below.

```
RECORD Square IS {INTEGER position, STRING player, INTEGER
pointer}
```

Using a programming language of your choice, declare a 2-D array called `gameboard` that could be used to store the relevant details of all 63 squares on the game board. 1

(c) A sub-program called `initialisation()` will be used to assign the initial values for each square of the game board.

(i) The pointer of each square is used to indicate whether the square is at the bottom of a ladder or the top of a snake.

- A value of 0 is used to indicate that the square is not at the bottom of a ladder or the top of a snake.
- A value of 1 to 63 is used to indicate that the square is at the bottom of a ladder or the top of a snake; the value stored is the position number of the square at the top of the ladder or the bottom of the snake.

For example:

- the pointer of square 22 is 36
- the pointer of square 51 is 0.

Using a programming language of your choice, write the code used to assign the appropriate pointers to the 2-D array variable `gameboard` declared in part (b) for:

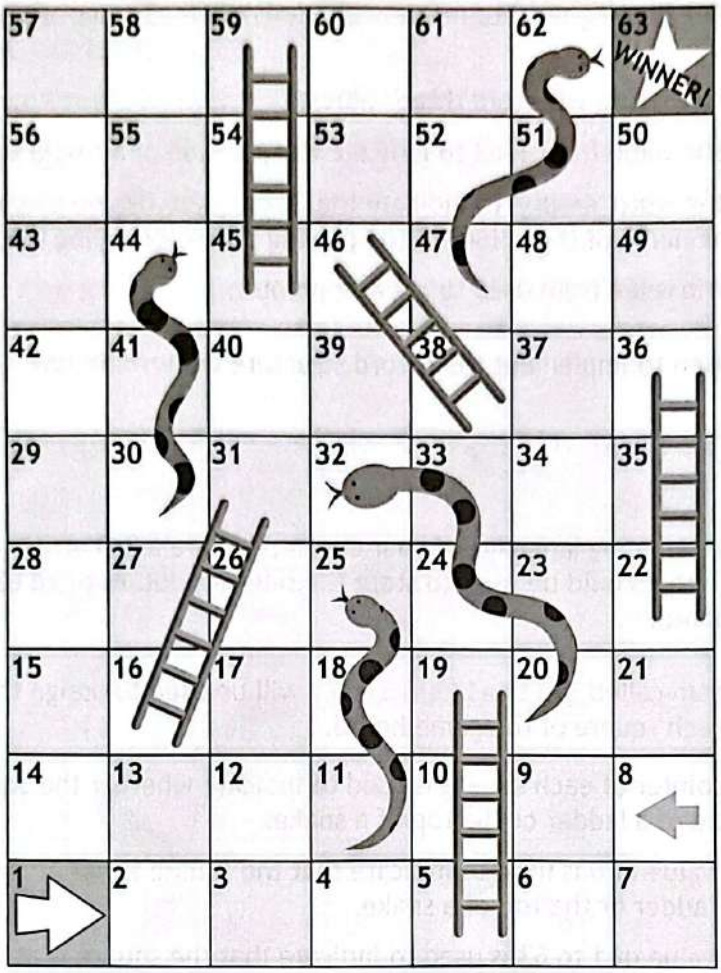
- square 37 of the game board
- square 44 of the game board. 1

(ii) The game board positions must follow a continuous path starting at the bottom left of the board at position 1, moving back and forward across each row of the board in the direction of the arrows, and ending up at the top right of the board at position 63.

Using pseudocode, design an algorithm to assign positions 1–63 to the 2-D array variable `gameboard` declared in part (b) above. 2

4. (continued) MARKS

The layout of the game board has been repeated below.



(d) Several rules are used during gameplay.

(i) Rules 1 and 2 below are used to move a player and work out their new position.

Rule 1:	During the game, players take it in turn to roll a 6-sided dice
Rule 2:	Players move forward the number of squares indicated by the dice: for example, if a player is currently on square 4 and rolls a 5, then the player moves to square 9

The algorithm for sub-program `rules12()` which will be used to apply rules 1 and 2 is shown below.

1. set `move` = random(1–6)
2. search the 2-D `gameboard` array to determine the current position of the player represented by the variable `colour`
3. apply rule 2 to assign a value to the variable `newPosition` which indicates the new position of the player

Using pseudocode, refine steps 2 and 3 of the algorithm for the `rules12()` sub-program. 3

MARKS

4. (d) (continued)

(ii) Rules 3 and 4 below are used to check for a win and process any bounce back needed.

Rule 3:	Players must finish exactly on square 63 to win
Rule 4:	If a player rolls too high a number, they 'bounce' back from square 63; for example, if a player is currently on square 61 and rolls a 5, then the player moves forward 2 to square 63 and then bounces back 3 to square 60

Using pseudocode, design the algorithm for the `rules34()` sub-program. 2

(iii) Rules controlling what happens when a player finishes on a square at the bottom of a ladder or the top of a snake are provided below.

Rule 5:	If a player is on the square at the bottom of a ladder, then `newPosition` must be updated to indicate that the player is now at the top of the ladder
Rule 6:	If a player is on the square with a snake's head, then `newPosition` must be updated to indicate that the player is now at the bottom of the snake

Using pseudocode, design the algorithm for the `rules56()` sub-program which will be used to apply rules 5 and 6 and update value of `newPosition`. 2

(e) Explain why the test plan for this program must include integrative testing. 2

[END OF SECTION 1]

[Turn over

SECTION 2 — DATABASE DESIGN AND DEVELOPMENT — 20 marks

MARKS

Attempt ALL questions

5. A concert venue is developing a booking system. There will be two types of users in the system: customers and administrators, and each user can perform specific tasks.

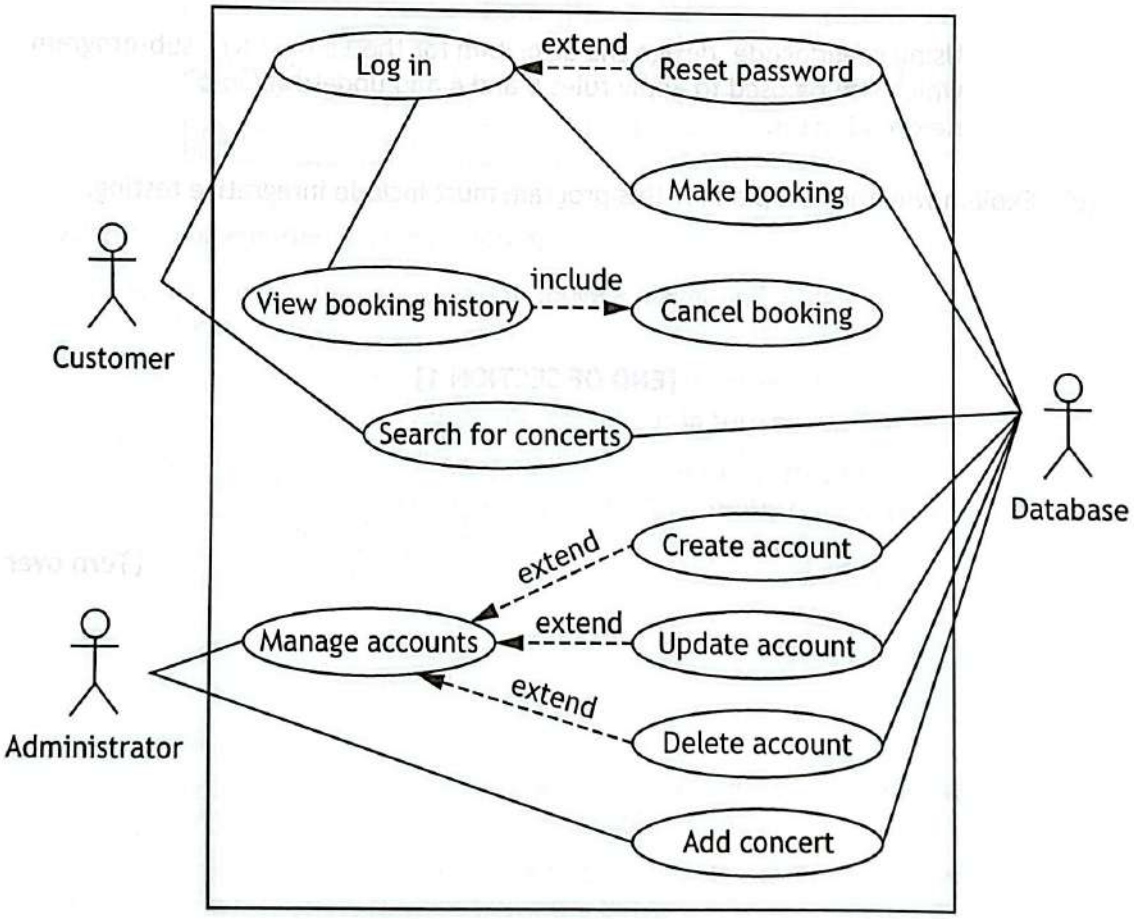
Customer tasks:

- log in to the system using their username and password
- reset the password if it has been forgotten
- search for concerts by date or performer
- make bookings for concerts
- view booking history and cancel a booking if necessary.

Administrator tasks:

- perform all tasks that a customer can perform
- manage customer accounts (create, update, or delete accounts)
- add details of new concerts.

(a) A UML use case diagram has been produced based on the description above. Identify two errors in this UML use case diagram. 2



5. (continued)

(b) A database developer is hired to develop the booking system.

The concert venue provides the developer with the following rules that the system must satisfy:

- registered performers may be allocated to play at zero, one or more concerts
- each concert must be associated with a single performer, and this must be recorded when the concert details are added to the database
- each concert will be identified by combining its concertDate, startTime and performerID
- each booking will be identified by combining its bookingDate with the customerID, concertDate and startTime
- once registered, customers can book tickets for one or more concerts.

During the analysis of the database requirements, the developer has identified four entities: Performer, Concert, Booking and Customer.

(i) Explain why Performer would be a strong entity. 1

(ii) Explain why Concert would be a weak entity. 1

(iii) Describe one benefit of using a surrogate key in the Booking entity. 1

(c) A query will be used to find details of customers who have made at least 5 bookings for concerts that will take place in May or June 2026.

A partially complete query design is shown below.

Using appropriate Advanced Higher operators, state the missing entries A, B and C needed to complete this query design. 2

Field(s)/ calculation(s)	customerID
Table(s)	Customer, Booking, Concert
Search criteria	A
Grouping	customerID
B	C
Sort order	

[Turn over

6. A community centre offers online classes in a range of subjects. Details of members, classes and enrolments are stored in three tables of a relational database. MARKS

The data dictionary showing the design of the `Member` table is shown below.

Attribute Name	Key	Type	Size	Required	Validation
memberID	PK	varchar	4	yes	
firstName		varchar	30	yes	
surname		varchar	40	yes	
email		varchar	200	yes	
dateOfBirth		date		no	

(a) Explain the impact of the chosen data types and sizes in the `Member` table on both the implementation and testing of the database. 2

Sample data for the `Member`, `Class` and `Enrolment` tables is shown below.

Member				
memberID	firstName	surname	email	dateOfBirth
M001	John	Doe	john.doe@example.com	1990-05-15
M002	Jane	Smith	jane.smith@example.com	1985-10-20
M003	Alice	Brown	alice.brown@example.com	2000-03-12
M004	Bob	Johnson	bob.johnson@example.com	1998-07-04
M005	Charlie	Lee	charlie.lee@example.com	1992-11-11
M006	Emma	Wilson	emma.wilson@example.com	2001-08-18

Class				
classID	className	category	capacity	cost
CLS101	Yoga Basics	Fitness	15	50
CLS102	Advanced Painting	Art	10	75
CLS103	Photography 101	Photography	20	100
CLS104	Guitar for Beginners	Music	25	55
CLS105	Fitness Bootcamp	Fitness	30	80
CLS106	Creative Writing	Literature	15	65

Enrolment					
enrolCode	memberID	classID	enrolDate	paid	startDate
E001	M001	CLS101	2024-11-01	25	2024-11-01
E002	M001	CLS102	2024-10-01	50	2024-10-01
E003	M002	CLS106	2024-11-16	30	2024-11-15
E004	M003	CLS104	2024-10-06	30	2024-10-05
E005	M005	CLS105	2024-10-12	40	2024-10-10
E006	M006	CLS101	2024-11-01	10	2024-11-01

MARKS

6. (continued)

(b) Making use of the `IN` operator, write the SQL query needed to display details of classes that do not have any enrolments. 2

(c) Both queries below can be used to display a list of members who are enrolled in classes.

Query 1

```
SELECT memberID
FROM Enrolment
WHERE classID = ANY (
    SELECT classID
    FROM Class );
```

Query 2

```
SELECT memberID
FROM Enrolment
WHERE EXISTS (
    SELECT classID
    FROM Class
    WHERE Class.classID = Enrolment.classID );
```

Compare the use of the `ANY` and `EXISTS` operators in the two queries above.

In each case, you should consider what result(s) the subquery returns and how the outer query uses those results. 3

(d) The `Member` table is to be removed from the database.

(i) Write the SQL statement to implement this. 1

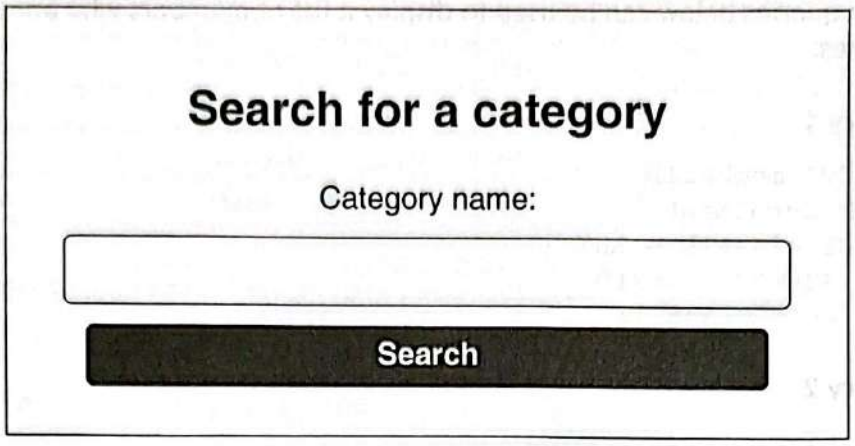
(ii) With reference to relationship participation, explain the impact of the SQL statement in part (i). 1

[Turn over

MARKS

6. (continued)

(e) Members can access a website that allows them to search for classes that match the category entered.



An extract of the form code for the search page is shown below.

```
...
<form action="searchCategory.php" method="GET">
<h2>Search for a category</h2>
<p>Category name:</p>
<input type="text" id="category" name="category" required>
<input type="submit" value="Search">
</form>
...
```

(i) Explain why the GET method is appropriate for this form. 1

(ii) Describe one additional type of data validation for the category name entry. 1

(f) After it has been in use for a month, members report that the search functionality is returning inaccurate search results.

State the type of maintenance that would be required in this situation. Justify your answer. 2

[END OF SECTION 2]

SECTION 3 — WEB DESIGN AND DEVELOPMENT — 20 marks

MARKS

Attempt ALL questions

7. A bank is developing an appointment booking system. There will be two types of users in the system: customers and administrators, and each user can perform specific tasks.

Customer tasks:

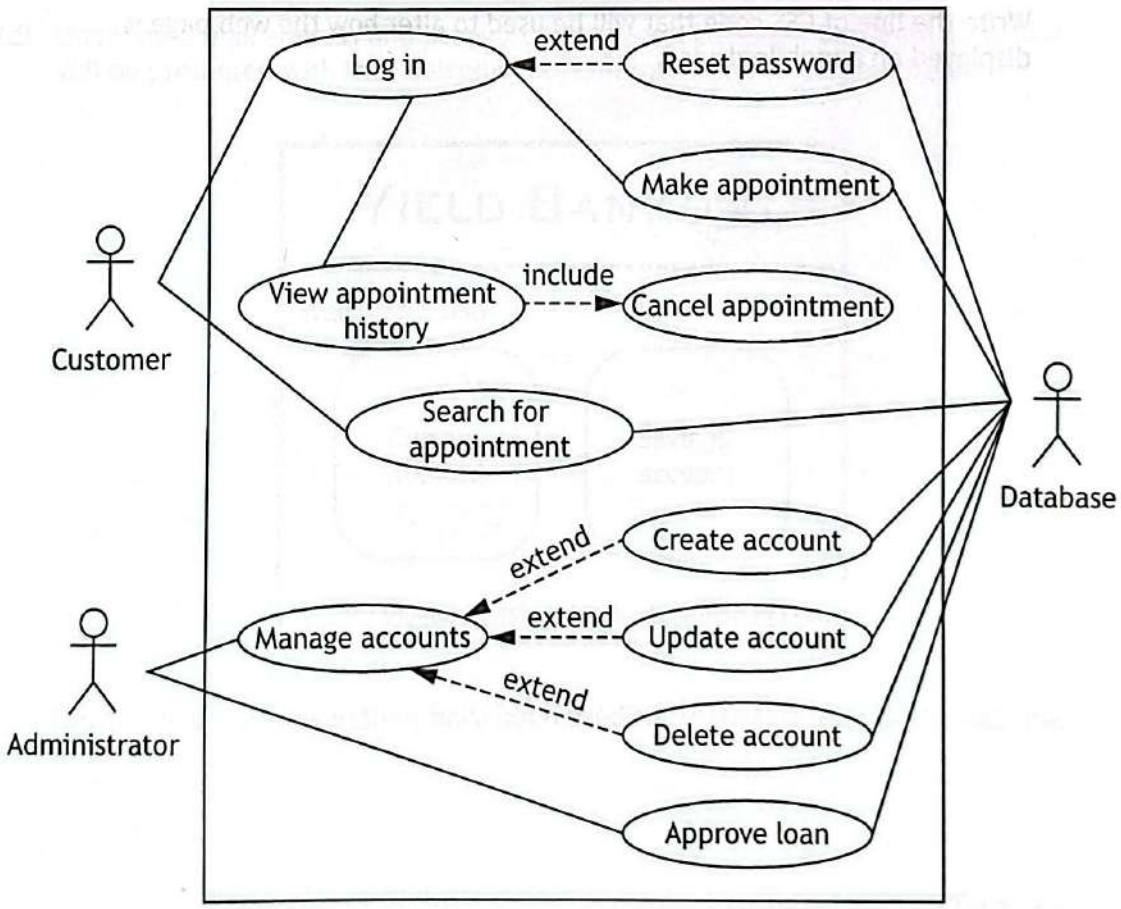
- log in to the system using their username and password
- reset the password if it has been forgotten
- search for a suitable appointment using appointment date and time
- make an appointment to discuss a loan
- view details of an appointment that has already been made and cancel it if necessary.

Administrator tasks:

- perform all tasks that a customer can perform
- manage customer accounts (create, update, or delete an account)
- approve a customer loan.

(a) A UML use case diagram has been produced based on the description above.

Identify two errors in this UML use case diagram. 2



MARKS

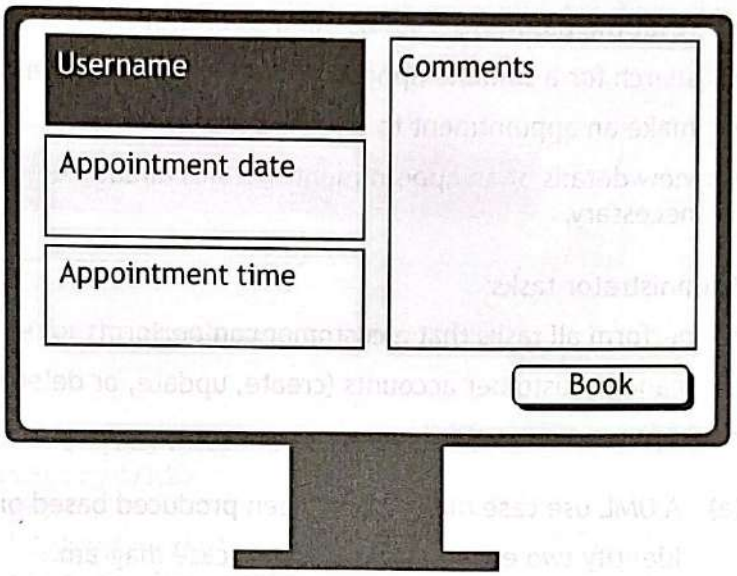
7. (continued)

(b) Customers will be able to view the new appointment booking system on mobile phones and desktop computers.

The design for each version of the appointment system is shown below.

mobile phone design

desktop computer design



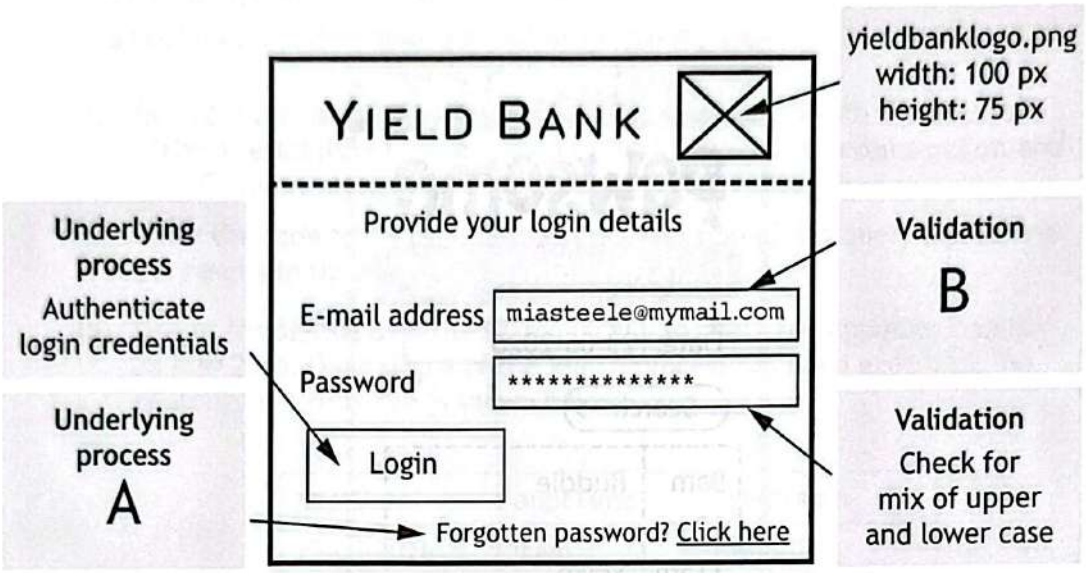
Write the line of CSS code that will be used to alter how the web page is displayed on a mobile device. 1

MARKS

7. (continued)

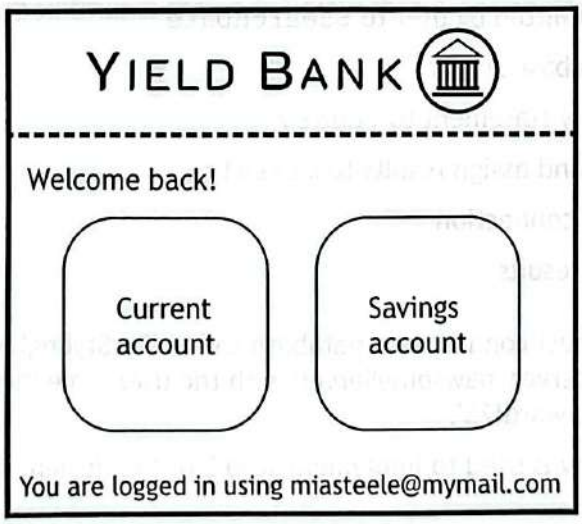
(c) The bank also provides an online banking service. Customers log in using their e-mail address and password.

The wireframe below shows login details for the customer Mia Steele.



Complete the wireframe design by providing the missing details for the underlying process labelled 'A' and suitable validation for the e-mail address labelled 'B'. 2

(d) Once the e-mail address and password has been successfully authenticated, Mia will be presented with the 'Welcome' page shown in the screenshot below.



Explain how session variables have been used to create this page of the website. 1

[Turn over

MARKS

8. The owner of a pet styling salon has recently introduced a database-driven website. The website is used by pet stylists who work at the salon.

Screenshot 1 below shows the search facility which is used by the pet stylists each morning to display a list of appointments for the day.

Screenshot 1

The design of the search process is shown below.

1. Assign date submitted by user to `$searchDate`
2. Connect to database server
3. Assign SQL query statement to `$query`
4. Execute query and assign results to `$results`
5. Close database connection
6. Process search results

(a) The website must connect to a database called 'PetStyling' which is hosted on the database server 'pawsomeServer' with the username 'petStylist' and password 'pa$$word!23'.

The code below is used to implement step 2 of the design, but generates an error.

```
mysqli_connect("PetStyling", "pawsomeServer", "petStylist",
"pa$$word!23");
```

Rewrite this code to correct the error. 1

MARKS

8. (continued)

(b) When the search is executed by the database server, one of the following three outcomes will be generated:

- execution failed
- no bookings found for date provided
- 5 bookings found — details in the table below.

(i) Before the search is executed at step 4, a connection with the database server is established and assigned to the PHP variable `$connection` and the SQL query statement is stored in the PHP variable `$query`.

Write the code to check for successful execution of this query and assign the results to the PHP variable `$results`. 2

(ii) One of the stylists uses the search facility to check her appointments for 23 May 2026. Once step 4 of the search process has been executed, the contents of `$results` is shown below.

apptDate	apptTime	petName
23-05-2026	9 am	Buddie
23-05-2026	11 am	Spike
23-05-2026	12 pm	Rosie
23-05-2026	1 pm	Goldie
23-05-2026	2 pm	Disco

Using pseudocode, refine step 6 to process the search results and display the list of appointments shown in **Screenshot 1** on the previous page. 2

[Turn over

MARKS

8. (continued)

(c) Screenshot 2 below shows the page used by the stylists to rate the behaviour of a pet during an appointment.

Screenshot 2

The ratings used in the drop-down list are assigned to the PHP variable `$ratings` as shown in the incomplete code below.

```
<?php
    $ratings = ["Green", "Yellow", "Red"];
    // drop-down list of ratings
    ...
?>
```

Write the code needed to implement the drop-down list using the values stored in `$ratings`. 2

(d) The updated behaviour ratings for each pet are stored in a database table called `Pet`. A sample of the data stored in this table is shown below.

petID	...	greenRatings	yellowRatings	redRatings	banned
098	...	10	1	0	FALSE
171	...	0	2	2	TRUE
340	...	4	2	0	FALSE
999	...	3	1	2	FALSE

MARKS

8. (d) (continued)

(i) At the end of each day, an SQL query is used to retrieve the full details of all pets stored in the `Pet` table and assign the results to the PHP variable `$allPets`.

The query results are then processed by applying the following rules:

- Data associated with pets that have already been banned from the salon is ignored, for example petID 171.
- 10 green ratings result in a 10% discount being awarded and the value in green ratings field is reset to 0.
- 3 yellow ratings result in a 15% surcharge being added and the value in the yellow ratings field is reset to 0.
- 2 red ratings result in the pet being banned from the salon; the red ratings value is not reset but the value of banned field is changed to TRUE.

Using pseudocode, design an algorithm to process the query results. The output should indicate that a discount has been awarded, a surcharge has been added, or the pet has been banned. The database should be changed where appropriate. 3

(ii) The manager of the salon needs to know how many pets have been banned.

Write the SQL query to perform this task. 2

(e) The salon owner has decided to add an artificially intelligent chatbot feature to the website.

State the type of maintenance that would be required in this situation. Justify your answer. 2

[END OF SECTION 3]

[END OF QUESTION PAPER]