National Qualifications 2025

X816/77/11 Computing Science

FRIDAY, 25 APRIL
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.

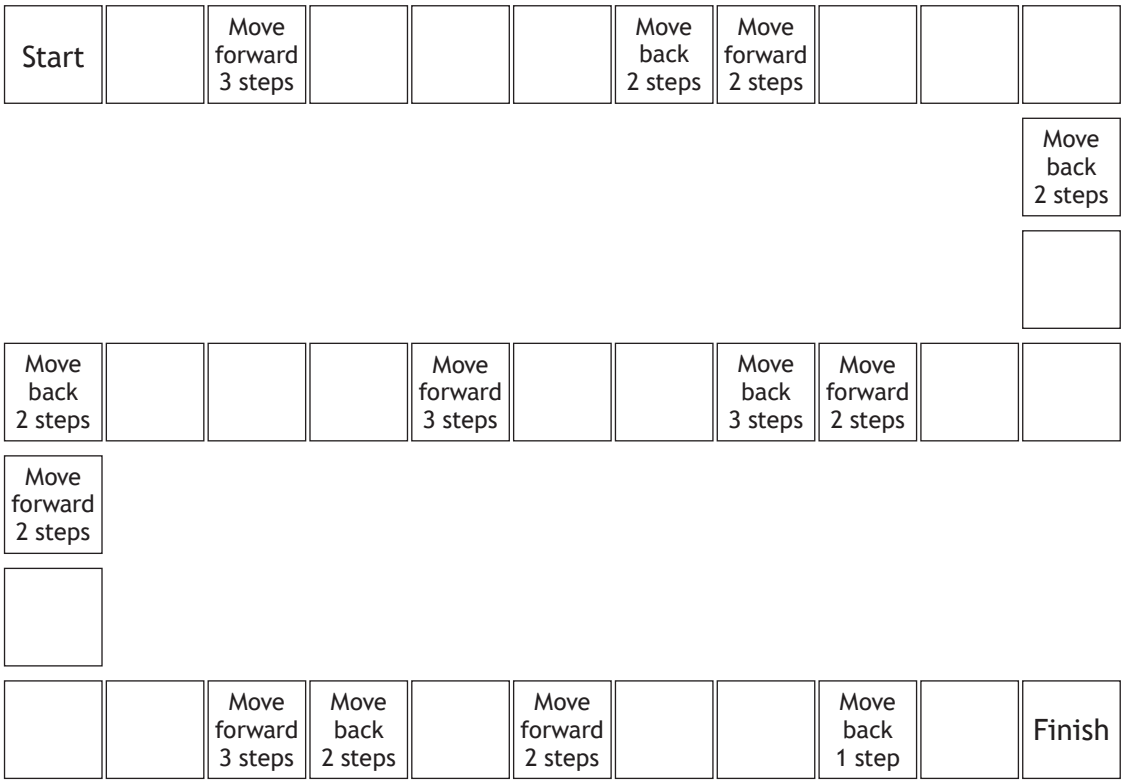
Before leaving the examination room you must give your answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

MARKS

SECTION 1 — SOFTWARE DESIGN AND DEVELOPMENT — 35 marks

Attempt ALL questions

1. An online version of a board game is being developed where the wording in each square on the game board is stored as a node in a linked list. The layout of the game board is shown below.



State the type of linked list that should be used. Justify your answer. **2**

MARKS

2. The share prices for the top 100 technology companies are stored in a program. The program uses an array of records called `companies` with fields for `companyName` and `sharePrice`. Sample data stored in the array of records is shown below.

companyName	sharePrice
Apex Industries	87.23
Blue Horizon Ventures	56.89
Celestial Technologies	102.34
…	…
Vertex Cybersecurity	79.56
Zephyr Wind Power	67.89
Zeta Blockchain Systems	110.23

A binary search algorithm will be used to search for a company's name and display its share price.

(a) State one reason why the data shown is suitable for this algorithm. **1**

(b) State the maximum number of comparisons required to find any company name using this algorithm. **1**

(c) The design of a binary search algorithm shown below contains three errors.

```
1.  set low to 0
2.  set high to 99
3.  set found to false
4.  get target company name
5.  while not found and low ≠ high
6.      set middle to (high − low) /2
7.      if target = company name at middle position then
8.          set found to true
9.      else
10.         if target is before company name at middle position then
11.             set high to middle − 1
12.         else
13.             set high to middle − 1
14.         end if
15.     end if
16. end while
17. if found then
18.     display share price at middle position
19. else
20.     display not found message
21. end if
```

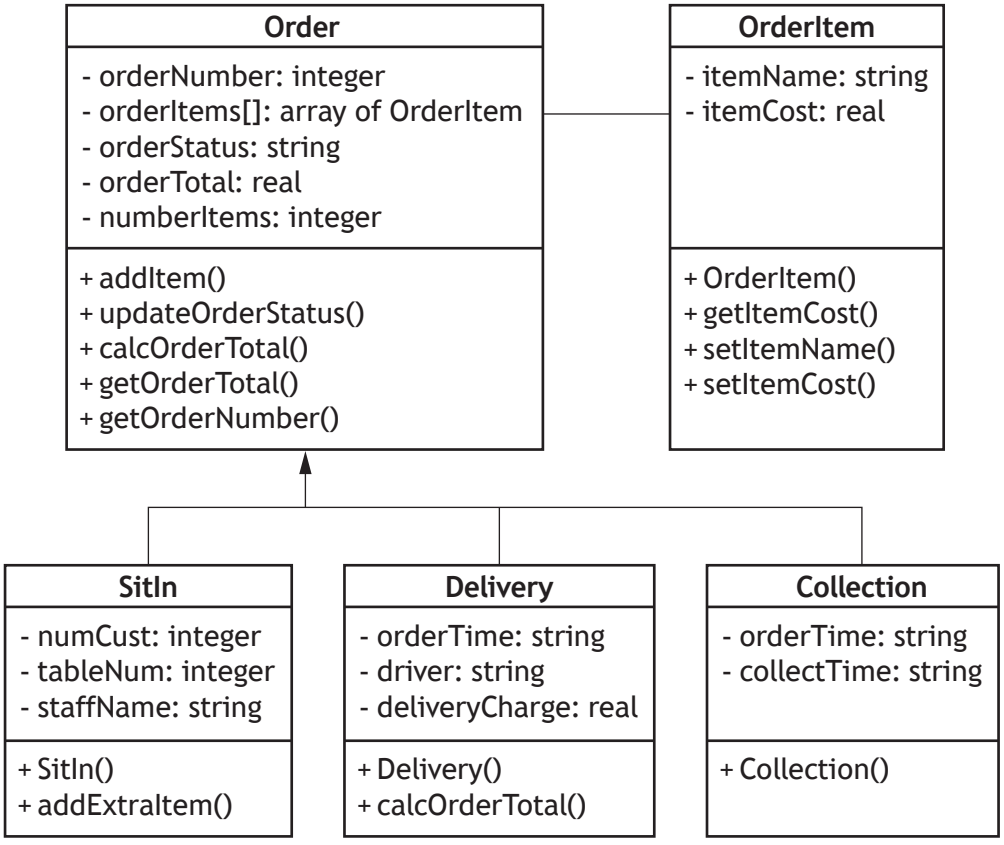
Identify the three lines that contain an error and describe the corrections required. **3**

3. FlavourFusion Cafe is creating an ordering system. Customers can make sit-in, delivery and collection orders.

The ordering system will be implemented using an object-oriented programming language. The following constraints will apply to the system:

- An order can contain a maximum of 50 items from the cafe menu.
- All items for delivery and collection orders must be added at the time an order is made.
- Extra items can be added to sit-in orders during the meal — for example, adding a dessert or a drink.
- All orders for delivery will have a delivery charge.

A simplified UML Class diagram of the system is shown below.



Some of the code used to implement the ordering system is shown on the page opposite.

3. (continued)

```
CLASS Order { INTEGER orderNumber, ARRAY OF OrderItem
orderItems[], STRING orderStatus, REAL orderTotal, INTEGER
numberItems }

METHODS
   …
   PROCEDURE calcOrderTotal()
      SET THIS.orderTotal TO 0
      FOR i FROM 0 TO THIS.numberItems –1 DO
         SET THIS.orderTotal TO THIS.orderTotal +
         THIS.orderItems[i].getItemCost()
      END FOR
   END PROCEDURE
   …
END CLASS


CLASS SitIn INHERITS Order WITH { INTEGER numCust, INTEGER
tableNum, STRING staffName }

METHODS

   CONSTRUCTOR (INTEGER howMany, INTEGER table, STRING staff )
      SET THIS.orderNumber TO <next order number>
      SET THIS.orderItems[0] TO <empty object of type OrderItem>
      SET THIS.orderStatus TO "In Progress"
      SET THIS.orderTotal TO 0.00
      SET THIS.numberItems TO 0
      SET THIS.numCust TO howMany
      SET THIS.tableNum TO table
      SET THIS.staffName TO staff
   END CONSTRUCTOR

   PROCEDURE addExtraItem(extraName, extraCost)
      SET THIS.numberItems TO THIS.numberItems + 1
      THIS.orderItems[THIS.numberItems].setItemName(extraName)
      THIS.orderItems[THIS.numberItems].setItemCost(extraCost)
   END PROCEDURE

END CLASS
```

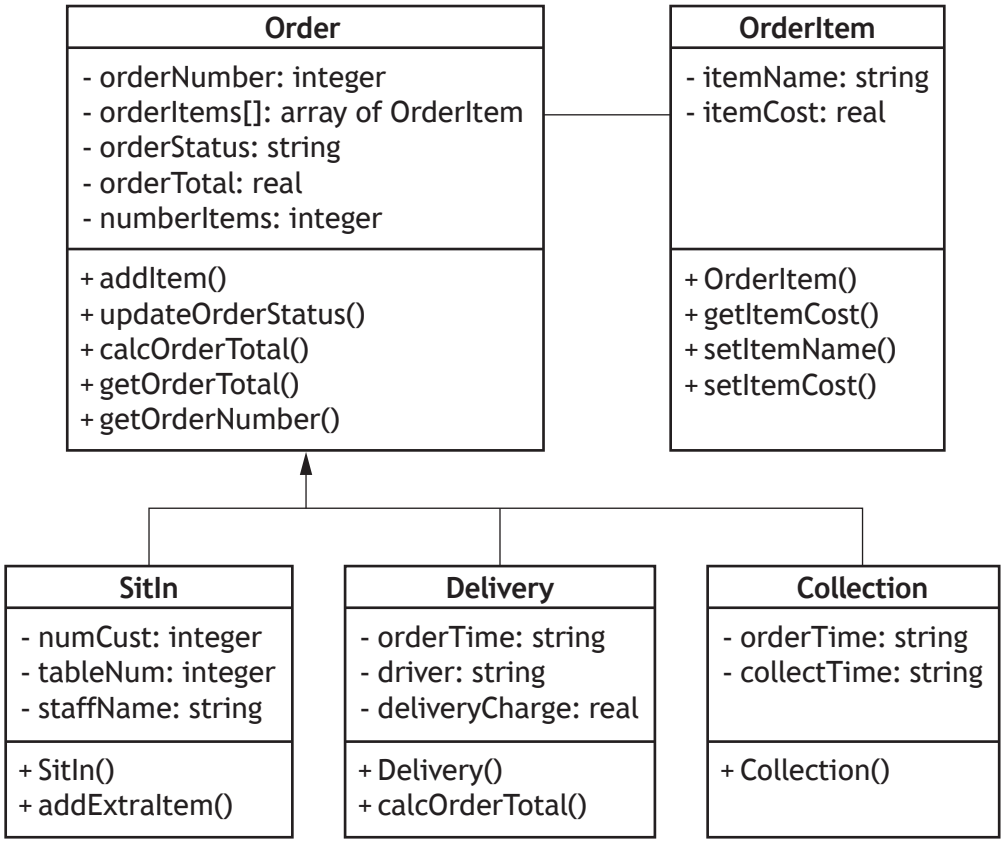
(a) Explain why the `Order` class does not need a constructor method. **1**

(b) Using appropriate object-oriented terminology, explain why the `calcOrderTotal()` method appears in both the `Order` and `Delivery` classes. **2**

[Turn over

3. (continued)

The UML class diagram for the ordering system is repeated below.



The following code is used during ongoing testing to check whether the system is working correctly.

Line 1
```
DECLARE order1 INITIALLY Delivery (1, [<array of
OrderItem>], "In Progress", 0.0, 4, "18:07",
"Jemma", 3.50)
```

Line 2
```
DECLARE order2 INITIALLY SitIn (2, [<array of
OrderItem>], "In Progress", 0.0, 5, 2, 7, "Max")
```

Line 3
```
DECLARE order3 INITIALLY Collection (3, [<array of
OrderItem>], "In Progress", 0.0, 7, "18:11",
"18:31")
```

Line 4
```
DECLARE orderList AS ARRAY OF Order INITIALLY
[order1, order2, order3]
```

Line 5
```
SEND order2.orderStatus TO display
```

Line 6
```
orderList[1].addExtraItem("Ice cream", 4.99)
```

3. (continued)

(c) At line 4, an array of `Order` objects is created.

Explain how it is possible for this array to store several different types of objects. **2**

(d) Explain why line 5 cannot be executed. **1**

(e) Line 6 has been written to add an extra item to an existing order.

(i) Explain why line 6 cannot be executed. **2**

(ii) Describe one way that an additional item could be successfully added to `orderList[1]`. Your answer should refer to the variable declarations used during ongoing testing. **1**

(f) At the end of each day, the owners want to view details of the three most expensive orders for that day.

Sample data in the `orderList` array that is processed at the end of a day is shown below.

orderNumber	orderItems	orderStatus	orderTotal	numberItems
...	...	...	...	...
34	< array of OrderItem >	Complete	45.97	6
35	< array of OrderItem >	Complete	56.87	8
36	< array of OrderItem >	Complete	23.34	3
37	< array of OrderItem >	Complete	73.29	9
...	...	...	...	...

Using pseudocode, design the procedure `bubbleSort(orderList)`.

This procedure will be used to sort the `orderList` array and display the `orderNumber` and `orderTotal` of the three most expensive orders in the sorted array.

Your procedure should make use of the bubble sort algorithm. **4**

[Turn over

MARKS

4. A program is being developed to help scientists track and analyse earthquake activity around the world. Data is stored about the latitude, longitude and magnitude of all earthquakes. The latitude and longitude identify the location of an earthquake, and the magnitude indicates the strength of the earthquake.

This data will be stored in a 2-dimensional array of real numbers called `events` as shown below. A total of 14 earthquake events have been recorded.

latitude	longitude	magnitude
34.1	−116.8	0.81
33.3	−116.2	0.86
31.6	−104.0	1.5
31.6	−104.0	1.9
38.8	−122.8	0.51
28.7	128.6	4.6
35.8	−118.6	0.96
61.9	−149.9	2.5
38.8	−122.7	0.75
31.7	−104.1	3.1
38.8	−122.8	0.75
64.5	−147.0	1
33.0	−115.6	1.58
38.8	−122.9	0.78

(a) Using a programming language of your choice, write the code used to declare a 2-dimensional array called `events` to store this data. **1**

(b) The insertion sort algorithm will be used to sort the `events` array in descending order of magnitude.

(i) Using a programming language of your choice, write the code needed to sort the `events` array using the insertion sort algorithm. **4**

(ii) Describe the evidence that should be gathered during testing to demonstrate that the data in the `events` array has been sorted correctly. **2**

4. (continued) **MARKS**

(c) Scientists want to spot local clusters of earthquake activity. An earthquake event is local if both the latitude and longitude are five or less from any other event.

For example, if the data for the earthquake at index 13 below is analysed, there are four other events (at indices 7, 10, 11 and 12) with a difference of five or less for both latitude and longitude.

A 1-dimensional array called `clusterSize` will be populated with the number of earthquakes local to each location.

	events			
index	**latitude**	**longitude**	**magnitude**	**clusterSize**
0	28.7	128.6	4.6	
1	31.7	−104.1	3.1	
2	61.9	−149.9	2.5	
3	31.6	−104.0	1.9	
4	33.0	−115.6	1.58	
5	31.6	−104.0	1.5	
6	64.5	−147.0	1	
7	35.8	−118.6	0.96	
8	33.3	−116.2	0.86	
9	34.1	−116.8	0.81	
10	38.8	−122.9	0.78	
11	38.8	−122.7	0.75	
12	38.8	−122.8	0.75	
13	38.8	−122.8	0.51	4

Using pseudocode, design an algorithm to populate the `clusterSize` array with a count of the number of earthquakes local to each earthquake event. **4**

(d) Once the application is released and has been used successfully for some time, the developers propose rewriting it as an object-oriented programming project with a class for earthquake events and an additional class to hold details of volcanic events.

(i) State the type of maintenance required and justify your answer. **2**

(ii) Explain why both economic and technical feasibility must be considered before implementing the object-oriented version. **2**

[END OF SECTION 1]

SECTION 2 — DATABASE DESIGN AND DEVELOPMENT — 20 marks **MARKS**

Attempt ALL questions

5. Describe two ways that the results from user surveys could be used at the analysis stage of a project. **2**

6. A company requires a database to hold details of their staff who are allocated to roles at events hosted in a number of venues. The structure of the proposed database is shown below.

Staff
staffID
firstName
lastName
contactNumber
address
dateOfBirth

Role
roleID
roleName
description
hourlyRate

Event
eventID
venueID *
eventName

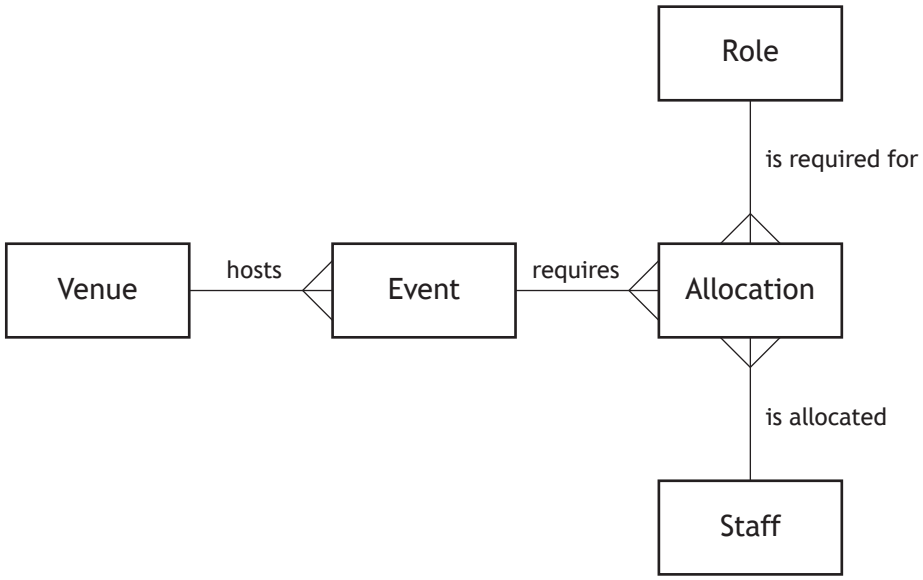
Venue
venueID
venueName
address

Allocation
staffID *
eventID *
roleID *
date
startTime
endTime

(a) The following constraints apply to the database:

- All events must be staffed, but not all staff will be allocated to an event.
- When staff are allocated to an event they are given a specific role, but not all roles are required for every event.
- An event is only added to the database if it has an associated venue, but venues may be added before they are used to host an event.

The incomplete entity-relationship diagram has been provided below.



Copy and complete the entity-relationship diagram. You should indicate:

- strong and weak entities
- relationship participation. **4**

(b) State one reason why the Allocation entity would benefit from the use of a surrogate key. **1**

6. (continued)

(c) The data dictionary below shows details of the Event entity.

Entity: Event					
Attribute name	**Key**	**Type**	**Size**	**Required**	**Validation**
eventID	PK	Int		Yes	Auto increment
venueID	FK	Int		Yes	Existing venueID from Venue table
eventName		Varchar	25	Yes	

Complete the following SQL statement used to create the `Event` table.

```
CREATE Event(
      eventID int NOT NULL AUTO_INCREMENT,
      venueID int NOT NULL,
      eventName varchar(25) NOT NULL,
      _____________________________
      _____________________________
      );
```

2

[Turn over

MARKS

7. A car company uses a relational database to record details of their sales. A sample of data stored in each table of the database is shown below.

Car						
carReg	**make**	**model**	**recommendedPrice**	**fuelType**	**colour**	**availability**
S81CGD	CNX	Fincas	18566	Petrol	Black	Sold
HS75 TRF	River	Duke	24899	Electric	Blue	Pending
RV36 NJU	Goudi	E3	26399	Hybrid	Red	Available
…	…	…	…	…	…	…

Order						
orderID	**customerID**	**carReg**	**salesID**	**salePrice**	**date**	**orderID**
1002	556	TR78 NGP	3	15239	2023-08-24	1002
1003	32	WR75 BCZ	7	17889	2024-11-03	1003
…	…	…	…	…	…	…

Salesperson				
salesID	**name**	**email**	**password**	**targetSales**
1	Brendan Anderson	banderson@rmail.com	!Brendan62	90000
2	Marisa MacDonald	mmacdonal@rmail.com	MaR!$a123	88000
3	Andrew Partridge	apartridge@rmail.com	AP1994	105000
4	Anthony Phillips	aphillips@rmail.com	Florida2025	65000
…	…	…	…	…

Customer			
customerID	**name**	**phone**	**email**
134	Caroline Wilson	07732953435	cw12312@kaloo.co.uk
135	Jude Brady	07478251489	jbrady1504@warmail.com
136	Aidan Abrol	07835294648	aab12345@ct.co.uk
…	…	…	…

(a) The SQL query below is used to find the total sales made by each salesperson who did not meet their target in March 2025.

```
SELECT Salesperson.name, SUM(salePrice)
FROM Salesperson, Order
WHERE Salesperson.salesID = Order.salesID
AND _____________________________________________
GROUP BY Salesperson.name
_____________________________________________ ;
```

Using appropriate Advanced Higher operators, write the missing conditions needed to complete this query. **2**

7. (continued)

(b) The company is running a promotion for their sales team.

A salesperson who sells a car for a higher `salePrice` than the most expensive Goudi or CNX sold during April 2025 will receive a 5% bonus.

Below is the incomplete query used to identify sales staff who are due to receive a bonus.

```
SELECT Salesperson.name
FROM Salesperson, Order, Car
WHERE Salesperson.salesID = Order.salesID
AND Car.carReg = Order.carReg
AND ________A________ (
                        SELECT MAX(salePrice)
                        FROM Order, Car
                        WHERE availability = "Sold"
                        AND date LIKE "2025-04-%"
                        AND _______B___________
                        GROUP BY make
);
```

Using appropriate Advanced Higher operators, write the SQL code needed to complete the missing conditions A and B. **2**

(c) The following query is used to identify customers who may be ready to purchase an environmentally friendly car.

```
SELECT Customer.name, date, make, model
FROM Customer, Order, Car
WHERE Customer.customerID = Order.customerID
AND Car.carReg = Order.carReg
AND NOT EXISTS(
        SELECT Customer.name
        FROM Customer
        WHERE (fuelType = "Hybrid" OR fuelType = "Electric")
        AND (date LIKE "2024-%-%" OR date LIKE "2023-%-%")
);
```

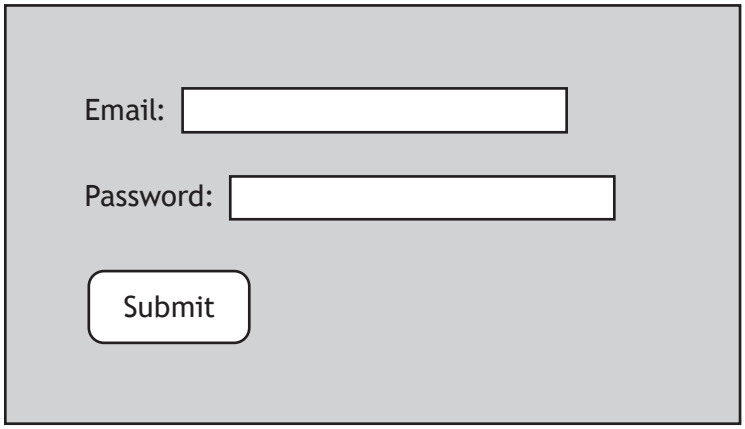
Explain how the subquery, with the use of `NOT EXISTS`, generates the required results. **2**

[Turn over

7. (continued)

(d) Orders are placed using an online database-driven website.

To access the ordering system, a salesperson must first login securely. The HTML form used for this purpose is shown below.



(i) Below is the incomplete HTML form code.

```
<form action = "login.php" _________A__________>
Email: <input type="text" id="email" name="email"
size="50" required > <br>
Password: <input type="text" id="password"
name="password" size="20" required> <br>
<_____________B_____________> <br>
</form>
```

Write HTML code needed to complete the missing parts A and B. **2**

(ii) Explain the need for integrative testing when developing a database-driven website. **2**

(iii) Describe how end-user testing would be carried out on a database-driven website. **1**

[END OF SECTION 2]

[Turn over for SECTION 3

DO NOT WRITE ON THIS PAGE

SECTION 3 — WEB DESIGN AND DEVELOPMENT — 20 marks **MARKS**

Attempt ALL questions

8. Describe two ways that the results from user surveys could be used at the analysis stage of a project. **2**

9. A beautician allows clients to make bookings for treatments using a database-driven website.

The website will be displayed on tablet devices and also output to A4 paper so that the beautician has a printed copy of the bookings to refer to as clients arrive.

The CSS code used to create the tablet layout is shown below.

```
@media screen (max-width: 700px) {
body {background-color: lightgrey}
.flower1img {width: 150px; height: 150px}
.flower2img {width: 150px; height: 150px}
.heading {font-family: Lucida Handwriting; font-size:28px;
text-align: center}
}
```

tablet layout

A4 paper layout

MARKS

9. (continued)

(a) Describe how the CSS for the tablet layout could be adapted to produce the A4 paper layout. **2**

(b) Explain the need for integrative testing when developing a database-driven website. **2**

(c) Describe how end-user testing would be carried out on a database-driven website. **1**

[Turn over

MARKS

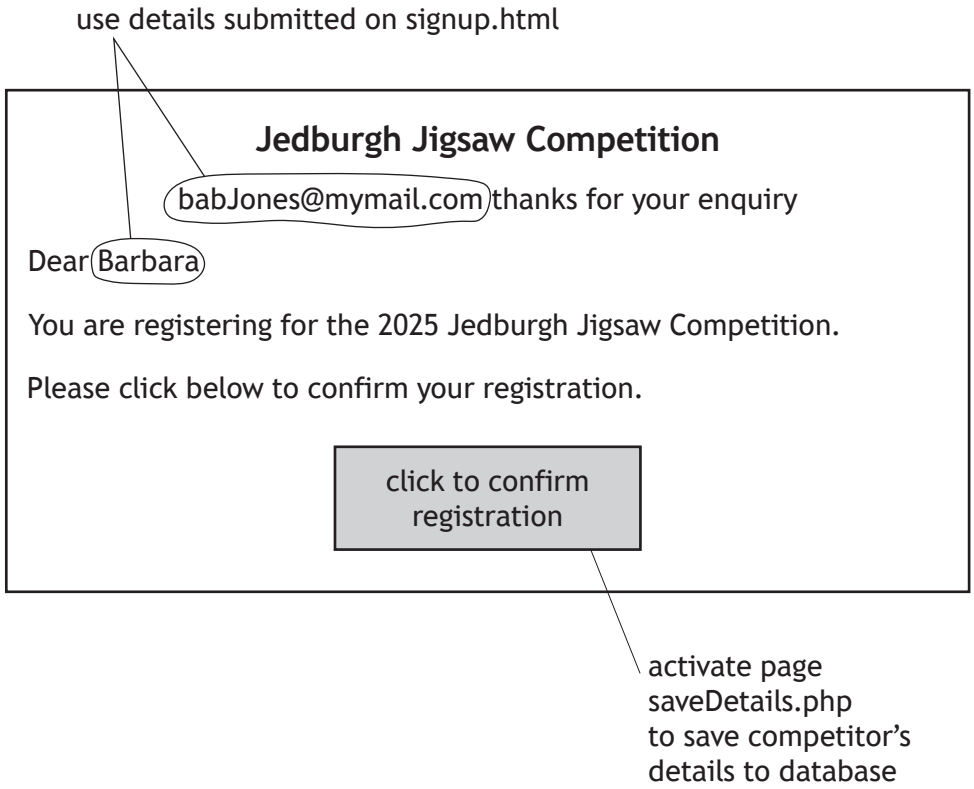
10. The Jedburgh Jigsaw Competition is held each year. Jigsaw enthusiasts can register to take part in the competition and view the results on the competition website.

Data about each competitor is stored in an online database in a table called `Competitor`. The structure of the `Competitor` table is shown below:

Competitor
competitorID
forename
surname
email
timeTakenRound1
timeTakenRound2
competitorPoints

(a) Competitors register using a sign-up form on the page `signup.html`. The form data is then submitted to the PHP page `confirmation.php`.

(i) The layout produced by the page `confirmation.php` is shown in the wireframe design below.



Explain how sessions and session variables would be used in this situation. **3**

10. (a) (continued)

(ii) Before the form data can be processed, the website must first connect to the database server.

Write the PHP code needed to connect to the database and assign the connection to the variable `$link`. Your code should make appropriate use of the following connection details:

```
database: jigsawFixture
password: pass1234
server: jigsaw1
user: admin
```

2

[Turn over

(b) The competition consists of two rounds. In each round, the time taken to complete the jigsaw is recorded. At the end of each round, points are awarded to the competitors who completed the jigsaw in the fastest times as follows:

- The competitor with the best time receives 8 points.
- The competitor with the next best time receives 5 points.
- The competitor with the third best time receives 3 points.
- The competitors with the next 21 best times receive 1 point.
- The remaining competitors do not receive any points.

It can be assumed that all times are unique.

The section of the code used to process the results of Round 1 is shown below.

```
…
Line 37   $query = "SELECT competitorID, forename, surname,
          timeTakenRound1 FROM Competitor ORDER BY
          timeTakenRound1 ASC";
Line 38   $round1 = mysqli_query($link, $query);
Line 39   echo "<p>Scores for Round 1</p>";
Line 40   echo "<table>";
Line 41   //display headings of HTML table for Round 1 results
Line 42   …
Line 43   //initialise $numProcessed to count number of
          competitors processed
Line 44   $numProcessed = 0;
Line 45   //initialise points allocated to a competitor
Line 46   $points = 0;
Line 47   //process round 1 results of an individual
          competitor
Line 48   while (($row = mysqli_fetch_array($round1)) and
          $numProcessed < 24)
Line 49   {
Line 50      //allocate points to an individual competitor
…
Line 62      //display individual competitor details in table
Line 63      _____________________
Line 64      //execute query to store the competitor's points
             in the database
Line 65      _____________________
Line 66      $numProcessed = $numProcessed + 1;
Line 67   }
Line 68   echo "</table>";
```

(i) Explain the significance of the SQL query at line 37. **1**

(ii) Explain how the complex condition at line 48 is used to control the `while` loop. **2**

10. (b) (continued)

(iii) Within the `while` loop, the points allocated to the competitors with the best times are used to update the variable `$points`.

Using pseudocode, design the section of code used to allocate points to the competitors. **2**

(iv) The screen shot below shows the output produced by the HTML table used to display the Round 1 Results.

Round 1 Results

Competitor	Time Taken	Points
Barbara Jones	02:32:24	8
Olive Oil	02:38:38	5
David Defau	02:39:58	3
Andy Peters	02:40:30	1
Lin Cadiz	02:41:19	1

Write the PHP code needed at line 63 to display the details of a single competitor in one row of the HTML table. **2**

(v) Once the points for an individual competitor have been allocated and displayed, a query is used to store the points in the database.

The incomplete code used at line 65 is shown below.

```
mysqli_query($link, "_____________________________________
WHERE competitorID = '$row[competitorID]'");
```

Write the statement needed to complete this query. **1**

[END OF SECTION 3]

[END OF QUESTION PAPER]

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE

[BLANK PAGE]

DO NOT WRITE ON THIS PAGE