National
Qualifications
2023 MODIFIED

X816/77/11 Computing Science

THURSDAY, 25 MAY
12:30 PM – 2:30 PM

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.

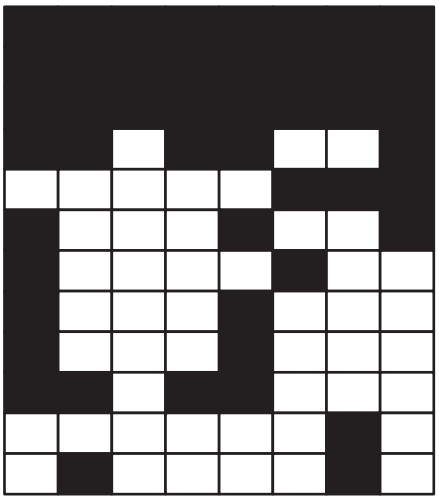
Before leaving the examination room you must give your answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

MARKS

SECTION 1 — SOFTWARE DESIGN AND DEVELOPMENT — 35 marks

Attempt ALL questions

1. A new game is being developed. When the game is being played, details of the black and white tiles will be stored in a 2-D array of character values as shown below.



game display

B	B	B	B	B	B	B	B
B	B	B	B	B	B	B	B
B	B	B	B	B	B	B	B
B	B	W	B	B	W	W	B
W	W	W	W	W	B	B	B
B	W	W	W	B	W	W	B
B	W	W	W	W	B	W	W
B	W	W	W	B	W	W	W
B	W	W	W	B	W	W	W
B	B	W	B	B	W	W	W
W	W	W	W	W	W	B	W
W	B	W	W	W	W	B	W

matching contents of the 2-D array

Using a programming language of your choice, declare a 2-D array called `gameBoard` capable of storing this grid. **1**

MARKS

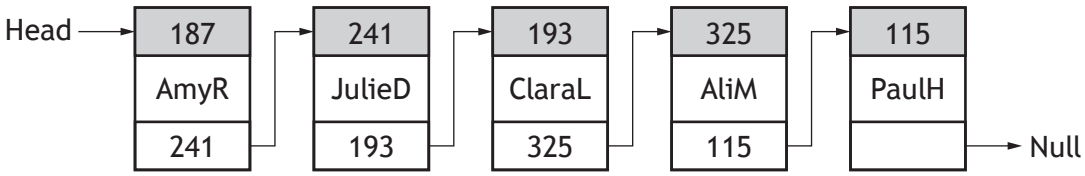
2. A ticketing website manages demand for newly released tickets by using a queue to store details of customers who are waiting to purchase tickets. The ticket queue will be implemented as a single linked list.

When tickets for events are released, the details of customers who wish to purchase tickets are added to the end of the linked list. As customers complete or cancel their purchases, their details are removed from the front of the linked list. If someone in the queue closes their browser, they lose their position in the queue and their details are removed from the linked list.

(a) Explain why this ticket order queue will be implemented as a single linked list rather than a double linked list. **1**

(b) The diagram below shows the contents of the linked list with details of several customers who are in the queue waiting to buy tickets.

AmyR is stored in memory location 187 and will be the next customer able to purchase tickets.



(i) Describe the changes that will take place within the linked list when user AmyR completes her purchase. **1**

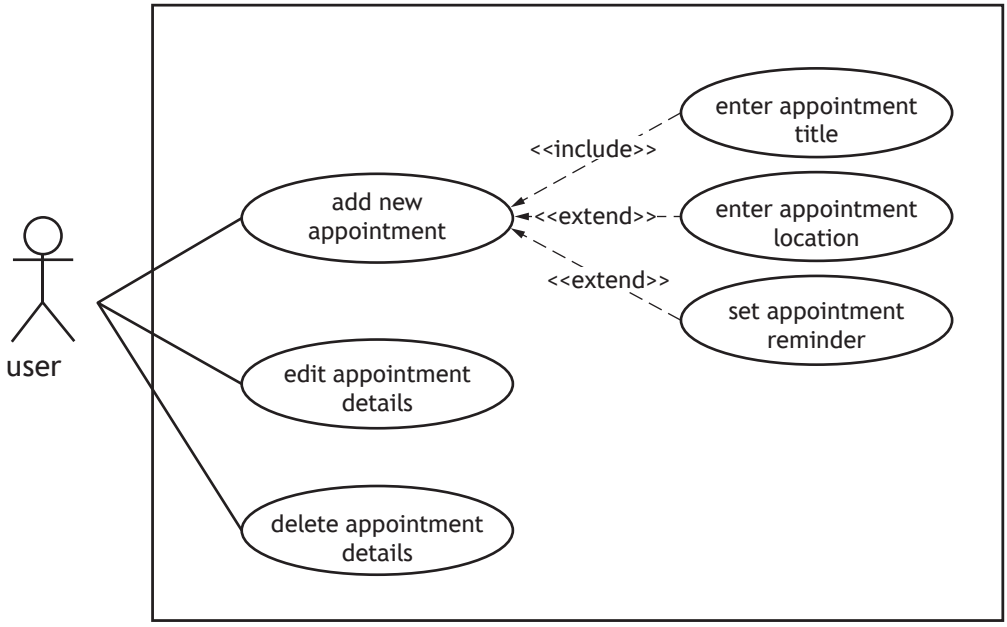
(ii) Describe the changes that will take place within the linked list when user ClaraL closes her browser. **1**

(iii) Describe the changes that will take place within the linked list when a new user, SamK, joins the queue. Assume that his username is stored in memory location 227. **1**

[Turn over

MARKS

3. A simplified UML use case diagram for an appointments app is shown below.



When creating a new appointment, users of the app must enter a title for the appointment. If they wish, users can also add a location for the appointment and set a reminder.

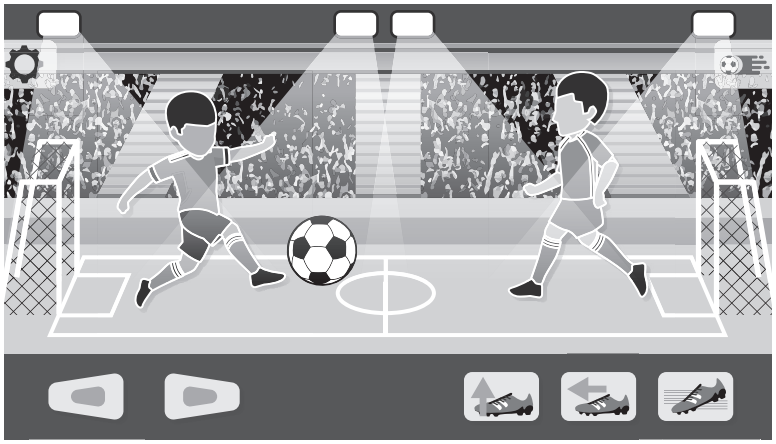
(a) State an additional actor that is required for this system. **1**

(b) With reference to the use case diagram above, explain the difference between include and extend relationships. **1**

[Turn over for next question

DO NOT WRITE ON THIS PAGE

4. A game is being developed where the player controls a footballer, playing against an online opponent.



When the game is played for the first time, a player must provide a nationality and a username. A new player starts with 1 point for their speed, jump, shoot, size and power characteristics. By winning games, players can gain extra points in each of these characteristics.

A simplified UML class diagram for a `Player` object is shown below.

Player
- speed: Integer - jump: Integer - shoot: Integer - size: Integer - power: Real - nationality: String - username: String
+ updateSpeed() + updateJump() + updateShoot() + updateSize() + calcPower() + getUsername() + getPower()

Some of the class declaration code is shown on the page opposite.

4. (continued)

```
CLASS Player IS { INTEGER speed, INTEGER jump, INTEGER shoot,
INTEGER size, INTEGER real, STRING nationality , STRING
username }

   METHODS

   CONSTRUCTOR(STRING nationality , STRING username)
      DECLARE THIS.speed INITIALLY 1
      DECLARE THIS.jump INITIALLY 1
      DECLARE THIS.shoot INITIALLY 1
      DECLARE THIS.size INITIALLY 1
      DECLARE THIS.power INITIALLY 1
      DECLARE THIS.nationality INITIALLY nationality
      DECLARE THIS.username INITIALLY username
   END CONSTRUCTOR

   PROCEDURE updateSpeed()
      SET THIS.speed TO THIS.speed + 1
   END PROCEDURE

   FUNCTION getUsername() RETURNS STRING
      RETURN THIS.username
   END FUNCTION

   FUNCTION getPower() RETURNS REAL
      RETURN THIS.power
   END FUNCTION
...
END CLASS
```

(a) Making use of appropriate object-oriented programming terminology, describe the effect of the following line of code. **3**

```
DECLARE newPlayer INITIALLY Player("French", "Player1626")
```

[Turn over

4. (continued)

(b) A player's power rating is calculated by working out the average of the speed, jump, shoot and size points.

Using a programming language with which you are familiar, write code to implement the `calcPower()` method. **2**

4. (continued)

(c) Players can join a league with nine other players. The league table is sorted in descending order of power.

Player1626	18.5
Player1762	17.25
Player2262	16.0
Player3562	14.75
Player1092	14.5
Player1827	12.75
Player1468	12.25
Player8372	11.5
Player6391	9.5
Player2864	9.0

(i) Using appropriate object-oriented terminology, explain the purpose of the code below. **2**

```
DECLARE league AS ARRAY OF Player INITIALLY [Null] * 10
SET league[0] TO newPlayer
```

(ii) The incomplete code below is used to arrange the league table details in descending order of power by applying a bubble sort algorithm to the `league` variable defined in part (i) above.

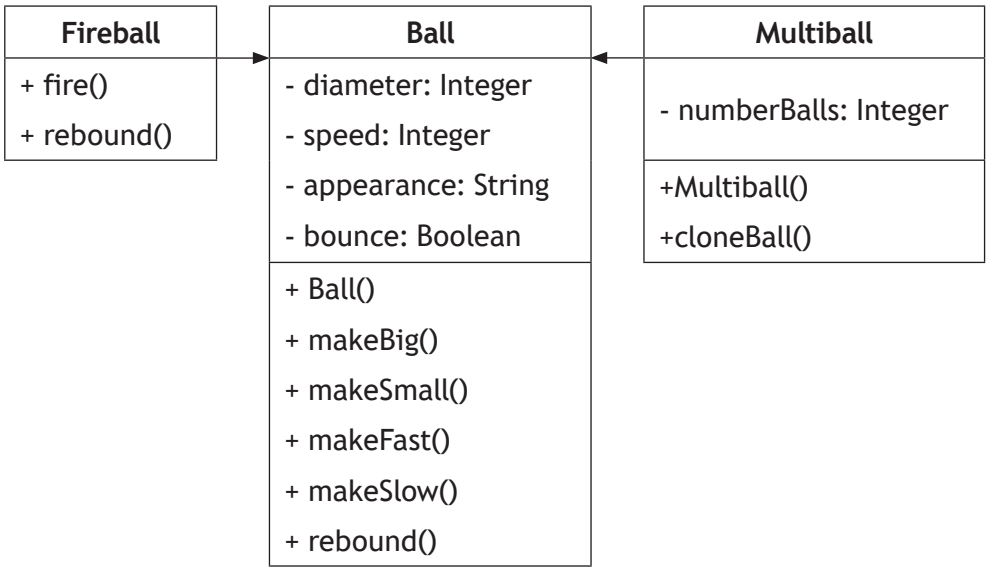
```
Line 2001   DECLARE numPlayers INITIALLY 9
Line 2002   DECLARE swapped INITIALLY TRUE
Line 2003   WHILE ____________________________
Line 2004      SET swapped TO FALSE
Line 2005      FOR loop FROM 0 TO numPlayers-1 DO
Line 2006         IF ____________________________
Line 2007            SET temp TO league[loop]
Line 2008            SET league[loop] TO league[loop +1]
Line 2009            SET league[loop+1] TO temp
Line 2010            ____________________________
Line 2011         END IF
Line 2012      END FOR
Line 2013      SET numPlayers TO numPlayers - 1
Line 2014   END WHILE
```

Using a programming language of your choice, write the code needed to complete Lines 2003, 2006 and 2010. **3**

4. (continued)

(d) During the game, players can collect power-ups that allow them to change the type of ball being used. For example, the ball can become bigger or smaller, faster or slower, it can become an unstoppable fire ball or split into multiple balls.

The UML class diagram below shows the classes used to represent each ball type that is possible.



(i) By referring to details in the UML class diagram above, explain what is meant by inheritance. **1**

(ii) The code used to define the `rebound()` method in the `Ball` and `Fireball` classes is shown below.

Ball Method

```
PROCEDURE rebound()
    SET THIS.bounce TO TRUE
END PROCEDURE
```

Fireball Method

```
OVERRIDE PROCEDURE rebound()
    SET THIS.bounce TO FALSE
END PROCEDURE
```

Name the feature of object-oriented programming illustrated by this example. **1**

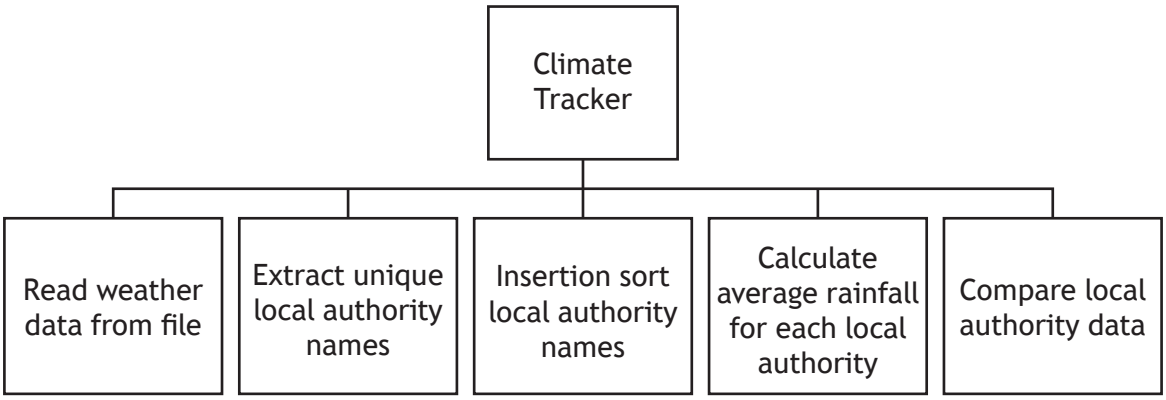
[Turn over for next question

DO NOT WRITE ON THIS PAGE

5. EnviroScot has set up 500 weather stations across Scotland to track the effect of climate change. Several weather stations have been placed in each of the 32 local authorities to ensure that the data gathered covers all areas of the country. **MARKS**

The rainfall (cm) for 28 February 2023 from all 500 weather stations has been stored in a CSV file.

A program is being developed to analyse the data. The structure diagram below shows the design of the program.



At the start of the program, the data is read from the CSV file into the program and stored in an array of 500 records called `readingsArray` with the following record structure:

```
RECORD reading IS { STRING place, STRING authority, INTEGER
rainfall }
```

A sample of the data held in `readingsArray` is shown below.

place	**authority**	**rainfall**
Inverurie	Aberdeenshire	5
Plockton	Highland	16
Inverary	Argyll and Bute	14
Braemar	Aberdeenshire	6
Cumbernauld	North Lanarkshire	11
Dunstaffnage	Argyll and Bute	15
Nairn	Highland	6
Paisley	Renfrewshire	11
Wick	Highland	7
…	…	…

(a) Using the data in the `readingsArray`, the program must calculate the average rainfall for each local authority and store the results in an array of 32 records called `rainfallArray`. The structure of each record in the `rainfallArray` array is shown below.

```
RECORD rainfall IS { STRING local, INTEGER averageRainfall }
```

(i) Using pseudocode, design an algorithm that will extract a unique list of local authority names from the `readingsArray` and store them in the `rainfallArray`. **3**

5. (a) (continued) **MARKS**

(ii) The local authority names stored in the `rainfallArray` array must be arranged in alphabetical order using the insertion sort algorithm. An incomplete algorithm for an insertion sort is shown below.

```
1.  set temp = ""
2.  set position = 0
3.  for loop = 1 to 31 do
4.      set temp to rainfallArray[loop].local
5.      set position = loop
6.      while _____________________________________
7.          _____________________________________________
8.          set position = position − 1
9.      end while
10.     _____________________________________________
11. end loop
```

Using pseudocode, write the instructions needed to complete the insertion sort design at lines 6, 7 and 10. **3**

(iii) In the calculation of the average rainfall for each local authority, any calculated averages with a decimal value must be rounded to the nearest integer.

Using pseudocode, design an algorithm to calculate the average rainfall for each local authority and store the results in the `rainfallArray`. **4**

(b) The program is required to compare the average rainfall for four local authorities. Users should be able to enter the names of four local authorities. The program will then use the binary search algorithm to find each local authority and its associated average rainfall.

The output from the program will be a diagram showing the average rainfall for each of the four local authorities entered by the user. Sample output from the program is shown below.

```
Average rainfall (cm) for the requested local authorities

Borders **************
Inverclyde ***********
Stirling *****
Highlands ****************
```

Using pseudocode, design an algorithm to:

- enter the names of the local authorities requested by the user
- apply the binary search algorithm to find the rainfall data for each local authority requested by the user
- display the diagram as shown in the sample output with one asterisk (*) representing 1 cm of average rainfall. **6**

[END OF SECTION 1]

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

Attempt ALL questions

6. A relational database system is being designed for a university to manage rentals for on-campus accommodation in three accommodation blocks: Clyde House, Hebridean Place, Lothian Way.

The system will store rental details in three separate tables: `Student`, `Accommodation` and `Rental`.

Sample data to be stored in these tables is shown below.

Student				
studentID	**firstName**	**surnameName**	**email**	**courseID**
SJME3456	Stephanie	Jones	stephanie@zmail.com	ME3456
JRCS4455	James	Ritchie	jgritchie@coldmail.com	CS4455
…	…	…	…	…

Accommodation		
accomID	**accomBlock**	**costPerMonth**
HEB24	Hebridean Place	450
CLY56	Clyde House	425
LOT24	Lothian Way	475
…	…	…

Rental			
startDate	**endDate**	**studentID**	**accomID**
03/09/2022	17/12/2022	SJME3456	CLY56
17/09/2022	28/05/2023	JRCS4455	HEB24
…	…	…	…

The following constraints apply to the university accommodation rental system:

- the system being developed will only store details of students who rent on-campus accommodation
- all accommodation is identified by a unique accommodation ID
- all students are identified by a unique student ID formed by concatenating the student's initials with their courseID
- accommodation that is being refurbished is not available for rental.

(a) Draw the entity-relationship diagram for the university accommodation rental system. Your diagram should clearly indicate:

- the cardinality of each relationship
- the relationship participation for each entity
- whether each entity is strong or weak. **3**

(b) Describe a potential problem with the primary key of the `Student` entity and suggest how this problem could be resolved. **2**

MARKS

7. A company sells computers using a database-driven website.

Maintenance is needed to ensure that the website is compatible with the latest 2023 versions of web technologies, including the server-side database used to store product and order details and the programming languages used in the development of the website.

(a) Name the type of maintenance required. **1**

(b) The project manager creates a Gantt chart to plan the development work that will be needed. The design section of the Gantt chart is shown below.

Design Tasks							
Data dictionary							
Entity-occurrence diagram							
Entity-relationship diagram							
Query design							

The project manager claims that use of this Gantt chart for planning will help to:

- improve efficiency and ensure work is completed on time
- manage resources.

By making reference to the section of the Gantt chart shown, explain why you agree or disagree with these claims. **2**

[Turn over

7. (continued) **MARKS**

(c) The following data dictionary has been produced when redesigning the relational database.

Entity: Customer					
Attribute name	**Key**	**Type**	**Size**	**Required**	**Validation**
custID	PK	varchar	5	yes	
firstName		varchar	15	yes	
lastName		varchar	20	yes	
address		varchar	50	yes	
email		varchar	30	yes	

Entity: Order					
Attribute name	**Key**	**Type**	**Size**	**Required**	**Validation**
orderID	PK	integer		yes	Auto increment
orderDate		date		yes	
custID	FK	varchar	5	yes	Existing custID from Customer table
orderSent		varchar	1	yes	Restricted choice: y, Y, n, N

Entity: Product					
Attribute name	**Key**	**Type**	**Size**	**Required**	**Validation**
prodID	PK	integer		yes	Auto increment
type		varchar	7	yes	Restricted choice: Desktop, Laptop, Tablet
make		varchar	10	yes	Restricted choice: Cell, Orange, Race, Sung
model		varchar	20	yes	
rating		integer		no	Range: 1 to 5
price		float		yes	>= 50.00

Entity: OrderProduct					
Attribute name	**Key**	**Type**	**Size**	**Required**	**Validation**
orderID	PK/FK	integer		yes	Existing orderID from Order table
prodID	PK/FK	integer		yes	Existing prodID from Product table
orderQuantity		integer		yes	>=1

Complete the following SQL statement used to create the `Order` table. **3**

```
CREATE TABLE Order(
  orderID int NOT NULL auto_increment,
  orderDate date NOT NULL,
  custID varchar(5) NOT NULL,
  orderSent varchar(1) NOT NULL
  _____________________________________
  _____________________________________
  _____________________________________
);
```

7. (continued)

(d) The SQL statement below is executed successfully.

```
SELECT type, make, model, price
FROM Product
WHERE price < 200 OR price > 400;
```

Re-write the `WHERE` clause using Advanced Higher logical operators. **2**

(e) The following query is used to display details of products that were ordered fewer than 12 times in April 2023.

```
SELECT *
FROM Product
WHERE EXISTS
   (SELECT prodID
   FROM OrderProduct, Order
   WHERE OrderProduct.prodID = Product.prodID
   AND orderDate LIKE "*/04/2023"
   GROUP BY prodID
   HAVING COUNT(*) < 12);
```

Explain how these results are generated by making reference to the use made of:

- the subquery
- the `EXISTS` operator
- the `HAVING` clause **3**

(f) A query is used to display the number of each type of product that costs less than £300.

The sample output from the query shown below is based on products made by Cell, Race and Sung and shows only those with fewer than five available.

type	Number of products available
Tablet	3
Desktop	2

Complete the following SQL query used to produce the sample output shown. **2**

```
SELECT type, COUNT(*) AS 'Number of products available'
FROM Product
WHERE price < 300
_____________________________
_____________________________
_____________________________
```

7. (continued)

(g) The changes made to the updated website must be tested.

The test plan includes the following test cases:

Test	Expected Result	Actual Result	Test Successful?
Select the following computer: Type = Desktop Make = Race Model = CL2	Specified computer selected using drop-down lists for type, make and model		
Add selected computer to the cart	Selected computer appears in cart		
Choose delivery date of Friday 17 June 2023 and make payment	Delivery date selected from calendar and payment made		

Two testers are chosen to complete these tests:

- Jill — a member of the development team
- Ben — an existing customer asked to test the updated website.

(i) Name the type of testing Jill is undertaking. Give one reason for your choice. **1**

(ii) Name the type of testing Ben is undertaking. Give one reason for your choice. **1**

[END OF SECTION 2]

MARKS

SECTION 3 — WEB DESIGN AND DEVELOPMENT — 20 marks

Attempt ALL questions

8. The CSS code used to display images on a website is shown below.

```
img
  { width: 50%;
  }

@media only screen and (max-width:767px)
  { img
    { width: 100%;
    }
  }
```

Explain the effect of this CSS code when displaying website content. **2**

[Turn over

MARKS

9. A query is executed and the `pupilID`, `firstName` and `lastName` are returned from the query. The returned values are stored in a PHP variable called `$result`. The contents of `$result` are shown below.

1	Agatha	Bertrand
2	Polly	N'mial

The following section of PHP code is used to display the query results in an HTML table.

```
...
Line 40    if ( mysqli_num_rows($result)  > 0 )
Line 41    {
Line 42    echo "<table>";

Line 43    // output each row of the table
Line 44    while ($row = _____________________________________)
Line 45    {
Line 46        echo "_________".$row["pupilID"]."_________".
           $row["firstName"]. "_________".
           $row["lastName"]."_________";
Line 47    }
Line 48    echo "</table>";
Line 49    }
...
```

(a) Explain the use made of the `mysqli_num_rows()` function at line 40. **1**

(b) Re-write the following lines to show the code needed to produce the HTML table:

(i) Line 44 **1**

(ii) Line 46. **1**

MARKS

10. A company sells computers using a database-driven website.

Maintenance is needed to ensure that the website is compatible with the latest 2023 versions of web technologies, including the server-side database used to store product and order details and the programming languages used in the development of the website.

(a) Name the type of maintenance required. **1**

(b) The project manager creates a Gantt chart to plan the development work that will be needed. The design section of the Gantt chart is shown below.

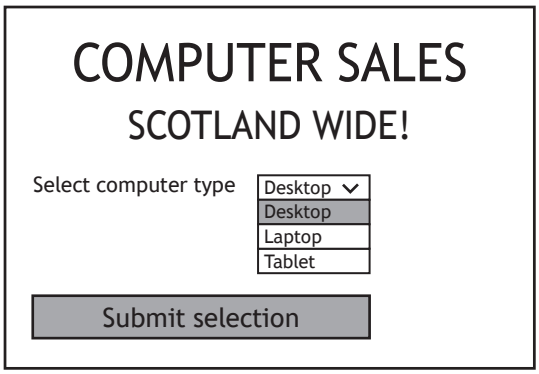
Design Tasks							
User interface design							
Design of server-side processes							
Develop low-fidelity prototype							

The project manager claims that use of this Gantt chart for planning will help to:

- improve efficiency and ensure work is completed on time
- manage resources.

By making reference to the section of the Gantt chart shown, explain why you agree or disagree with these claims. **2**

(c) A prototype of an updated web page is shown below. This page should allow the user to select the type of computer they wish to buy.



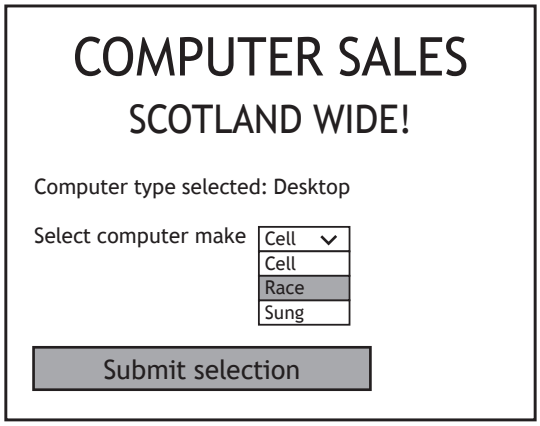
Screen 1 User selects 'Desktop', 'Laptop' or 'Tablet'

(i) Making appropriate use of the `name` and `value` attributes, write the HTML statements that would be used to implement the 'Select computer type' drop-down list shown in the prototype above. **2**

[Turn over

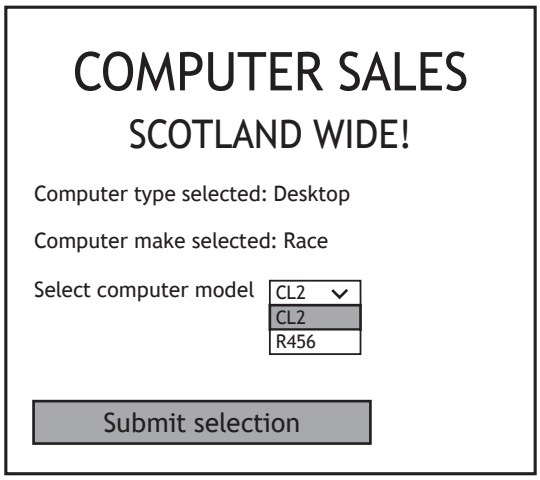
10. (c) (continued)

(ii) When computer type 'Desktop' is selected at Screen 1, Screen 2 shows the web page that is rendered.



Screen 2 User selects 'Make'

When the make 'Race' is selected at Screen 2, Screen 3 shows the web page that is rendered.



Screen 3 User selects 'Model'

Write the lines of PHP and HTML code required to create the following part of the output on Screen 3. This code should make use of the input selected by the user at Screens 1 and 2. **3**

Computer type selected: Desktop

Computer make selected: Race

10. (c) (continued)

(iii) The data required to generate the new drop-down list required for Screen 3 is extracted from the `Product` table of a database called `ComputerSales`.

Sample data stored in the `Product` table is shown below.

prodID	type	make	model	price
1	Desktop	Cell	C34	399
2	Desktop	Race	CL2	299
3	Desktop	Race	R456	499
4	Laptop	Sung	S34	359

The query used to extract this data from the database is stored in a PHP variable called `$query`.

Using PHP, write the code needed to successfully connect to the database and extract the values required for the 'Select computer model' drop-down list from the database. **3**

Your code should make appropriate use of the following connection details:

password = `Comp5A135`

server = `ComputerSales_Host`

user = `visitor`

(iv) Explain how the results returned from the query in (c) part (iii) above would be used to display the data shown in the drop-down list for Screen 3. **2**

Your explanation should refer to relevant HTML and PHP statements and constructs.

[Turn over

10. (continued)

(d) The changes made to the updated website must be tested.

The test plan includes the following test cases:

Test	Expected Result	Actual Result	Test Successful?
Select the following computer: Type = Desktop Make = Race Model = CL2	Specified computer selected using drop-down lists for type, make and model		
Add selected computer to the cart	Selected computer appears in cart		
Choose delivery date of Friday 17 June 2023 and make payment	Delivery date selected from calendar and payment made		

Two testers are chosen to complete these tests:

- Jill — a member of the development team
- Ben — an existing customer asked to test the updated website.

(i) Name the type of testing Jill is undertaking. Give one reason for your choice. **1**

(ii) Name the type of testing Ben is undertaking. Give one reason for your choice. **1**

[END OF SECTION 3]

[END OF QUESTION PAPER]