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Computer science

Standard level

Paper 2

6 May 2024

Zone A morning | Zone B morning | Zone C morning

1 hour

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Answer all of the questions from one of the options.
- The maximum mark for this examination paper is **[45 marks]**.

Option	Questions
Option A — Databases	1 – 3
Option B — Modelling and simulation	4 – 6
Option C — Web science	7 – 9
Option D — Object-oriented programming	10 – 13

Option A — Databases

- 1. Environmental systems and societies (ESS) students are collecting data about the plant species found on sand dunes as part of their internal assessment. The data is collected from 10 sites using a paper form (**Figure 1**).

The form shown in **Figure 1** is used to input data into the **Environment** database.

Figure 1: An example of a data collection form.

FIELD STUDY CENTRE

[LOGO]

Survey date:

Sample site:

Aspect:

Gradient:

Comments:

Species	Present	Coverage %
Marram grass	<input type="checkbox"/>	<input type="text" value="0"/>
Sand couch grass	<input type="checkbox"/>	<input type="text" value="0"/>
Sea holly	<input type="checkbox"/>	<input type="text" value="0"/>
Sea spurge	<input type="checkbox"/>	<input type="text" value="0"/>
Sea buckthorn	<input type="checkbox"/>	<input type="text" value="0"/>
Gorse	<input checked="" type="checkbox"/>	<input type="text" value="40"/>
Blackthorn	<input checked="" type="checkbox"/>	<input type="text" value="40"/>

(Option A continues on the following page)

(Option A, question 1 continued)

(a) State the data type for:

(i) Species [1]








(ii) Gradient [1]

(b) Outline **one** way that data validation could be carried out on the gradient attribute. [2]

Three of the tables in the **Environment** database are shown in **Figure 2**:

Figure 2: Three of the tables in the Environment database

Plant

<u>Plant_ID</u>	Species	Image	More fields
1	Marram grass	 (0)	
2	Sand couch grass	 (0)	
3	Sea holly	 (0)	
4	Sea spurge	 (0)	
5	Sea buckthorn	 (0)	
6	Gorse	 (0)	
7	Blackthorn	 (0)	

Note: The image is stored in the database as an attachment.

Site

<u>Site_ID</u>	Location	Aspect	Gradient
1	Seaward facing foreshore	West	8.2
2	Seaward facing upper slope of dune closest to the sea	West	8.0
3	Landward side of dune closest to the sea	East	7.9
4	First slack area between dunes	None	7.6
5	Seaward facing mid slope of dune second closest to the sea	West	7.8

(Option A continues on the following page)

(Option A, question 1 continued)

Distribution

<u>Plant_ID</u>	<u>Site_ID</u>	<u>Date</u>
1	1	14/10/2019
2	1	14/10/2019
...
...
6	7	14/10/2019
7	7	14/10/2019
...
6	9	14/10/2019
...
6	7	21/10/2019
7	7	21/10/2019

- (c) Construct an entity relationship diagram (ERD) for the Plant, Site and Distribution tables. [3]
- (d) Outline why a composite primary key is used for the Distribution table. [2]
- (e) Identify the steps to create a query to calculate the total number of sites where gorse has been found from the samples carried out on 14 October 2019. [4]
- (f) Explain how data consistency can be maintained in the **Environment** database. [3]

(Option A continues on the following page)

(Option A continued)

2. The Bucharesti School website allows parents to login and select school transportation for their children. If they select the school bus, they will have to pay for this service at the end of the month.
- (a) Identify the steps that take place in a transaction when a parent attempts to pay for the school bus at the end of a month. [3]
 - (b) Explain how the database management system (DBMS) prevents a record being updated by two parents simultaneously. [3]
- The students' personal details must be securely stored in the database.
- (c) Identify **two** roles of the database administrator at Bucharesti School. [2]
 - (d) Outline **two** ways that a database management system (DBMS) can be used to ensure the students' personal data remains secure. [4]
 - (e) Explain how the developers of the Bucharesti School database can ensure that it has been designed ethically. [6]

(Option A continues on the following page)

(Option A continued)

3. The ATHLETICS table contains information about athletics events.

Figure 3: The ATHLETICS table

Event	Type	SubType	Gender	OlymRec	WldRec
100	Track	Run	M	9.63	9.58
	Track	Run	F	10.62	10.49
200	Track	Run	M	19.30	19.19
	Track	Run	F	21.34	21.34
...
Long Jump	Field	Jump	M	8.90	8.95
			F	7.40	7.52
...
Shot Put	Field	Throw	M	22.52	23.12
	Field	Throw	F	22.41	22.63
...
Heptathlon	Track + Field	Multi	F	7291	7291
Decathlon	Track + Field	Multi	M	8893	9126

(a) Outline **one** reason why databases are normalized. [2]

(b) Outline why the data type for the Olympic Record attribute (OlymRec) cannot be an integer. [2]

The table can also be represented as:

ATHLETICS

(Event, Type, SubType, Gender, OlymRec, WldRec)

(c) Construct the 2nd Normal Form (2NF) of the unnormalized ATHLETICS relation shown above. [5]

(d) Outline why databases are normalized from 2nd normal form (2NF) to 3rd normal form (3NF). [2]

End of Option A

Option B — Modelling and simulation

4. A company designs new kitchens for customers. It has a shop that shows examples of the kitchen cabinets, sinks, wall tiles and floor tiles that can be included in the new kitchen.

When customers have chosen the items they would like for the new kitchen, a simulation is set up to show how these items would look.

- (a) State **three** variables that could be used for this simulation. [3]
- (b) Outline **two** rules that would need to be applied for this simulation to be created within the constraints of the customer’s kitchen. [4]
- (c) Outline **two** factors that would impact on the reliability of this simulation. [4]
- (d) Discuss the advantages and disadvantages of using simulation to design a fitted kitchen. [5]

5. A real estate agent makes use of electronic brochures to send to potential house buyers. These brochures contain details of the properties, including sets of photographs of the rooms and the different views from the property.

- (a) Outline the impact in terms of memory requirements on the potential house buyer’s device when viewing a brochure. [2]

The real estate agent decides to improve their brochures by using animated ‘walk-throughs’.

- (b) State the name of the process that relates the original photographs of the properties to the animated ‘walk-throughs’. [1]
- (c) Explain how ray tracing may be beneficial to the production of the real estate agent’s animations. [3]
- (d) Explain the ethical considerations for the use of animated ‘walk-throughs’ in the new brochures. [4]

(Option B continues on the following page)

(Option B continued)

6. A supermarket has set up a spreadsheet model to compare its sales for each quarter during the financial year 2020 to 2021.

This model, for each of the eight departments, shows the:

- quantity of units sold each quarter
- average units sold per quarter
- highest quarterly sales
- lowest quarterly sales.

Figure 4: The supermarket’s sales by department

	A	B	C	D	E	F	G	H	I
1	Sales (in thousands of units)								
2	2020 - 2021	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Whole year	Quarter average	Highest quarter	Lowest quarter
3	Bakery	9.4	10.2	14.7	10.2	44.4	11.1	14.7	9.4
4	Dairy	9.7	10.4	11.5	10.3	41.8	10.5	11.5	9.7
5	Delicatessen	6.1	7.8	5.7	6.1	25.7	6.4	7.8	5.7
6	Frozen	7.4	6.9	6.7	6.4	27.4	6.9	7.4	6.4
7	Fruit	11.6	14.3	19.6	17.7	63.3	15.8	19.6	11.6
8	Grocery	64.7	48.1	77.0	69.2	259.0	64.8	77.0	48.1
9	Meat	8.1	8.5	10.6	5.7	33.0	8.3	10.6	5.7
10	Seafood	13.2	8.7	17.7	9.1	48.6	12.2	17.7	8.7
11									
12	Target increase (%)								
13									
14	Target sales (in thousands of units)								
15	2020 - 2021	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Whole year	Quarter average	Highest quarter	Lowest quarter
16	Bakery								
17	Dairy								
18	Delicatessen								

(Option B continues on the following page)

(Option B, question 6 continued)

The manager of the supermarket plans to use this model in meetings with the eight department heads so that they can set targets for future sales.

(a) Identify the functions or formulas that could be used in the cells:

- (i) F3 [1]
- (ii) G3 [1]
- (iii) H3 [1]
- (iv) I3 [1]

This model needs to be developed to set targets for increasing the sales over the next financial year for the bakery department. The target percentage increase can be changed within the model.

(b) Design a spreadsheet model that will calculate the target sales for the bakery department.

The model will display the updated sales targets for each quarter, the whole year and the average per quarter. The initial sales target is an increase of 7%. [5]

(c) Describe **one** limitation of this model for predicting future profits. [2]

(Option B continues on the following page)

(Option B, question 6 continued)

The supermarket uses a second model to predict future sales increases based on previous performance. The spreadsheet in **Figure 5** is part of that model. For the year 2020 to 2021, it shows the:

- revenue for sales taken by each department in each quarter
- cost of purchasing the stock for the supermarket
- utility costs of running the store
- staff costs.

All values have been rounded to the nearest dollar.

Figure 5: The supermarket’s sales and costs by department.

	A	B	C	D	E	F	G	H	I
1	Revenues, costs and profits (\$ * 1000)								
2	2020-2021	Apr-Jun	Jul-Sept	Oct-Dec	Jan-Mar	Whole year	Quarter average	Highest quarter	Lowest quarter
3									
4	Revenues								
5	Bakery	23.4	25.4	36.8	25.4	111.1	27.8	36.8	23.4
6	Dairy	17.4	18.8	20.6	18.5	75.3	18.8	20.6	17.4
7	Delicatessen	23.1	29.7	21.6	23.1	97.5	24.4	29.7	21.6
8	Frozen	29.5	27.7	26.9	25.5	109.6	27.4	29.5	25.5
9	Fruit	17.4	21.5	29.4	26.6	94.9	23.7	29.4	17.4
10	Grocery	77.6	57.8	92.4	75.5	303.3	75.8	92.4	57.8
11	Meat	40.5	42.6	53.1	28.5	164.7	41.2	53.1	28.5
12	Seafood	56.0	37.0	75.1	38.5	206.6	51.7	75.1	37.0
13	Total	284.9	260.5	356.0	261.6	1163.0	290.8	366.7	228.5
14									
15	Wholesale costs								
16	Bakery	12.2	13.2	19.1	13.2	57.7	14.4	19.1	12.2
17	Dairy	9.9	10.7	11.8	10.6	43.0	10.8	11.8	9.9
18	Delicatessen	12.6	16.2	11.8	12.6	53.2	13.3	16.2	11.8
19	Frozen	15.3	14.4	14.0	13.3	56.9	14.2	15.3	13.3
20	Fruit	9.0	11.2	15.3	13.8	49.3	12.3	15.3	9.0
21	Grocery	48.4	36.0	57.6	47.1	189.1	47.3	57.6	36.0
22	Meat	35.8	37.6	46.9	25.1	145.5	36.4	46.9	25.1
23	Seafood	33.5	22.1	44.9	23.0	123.4	30.9	44.9	22.1
24	Total	176.7	161.4	221.3	158.7	718.1	179.5	227.1	139.4
25	Other costs								
26	Utilities	9.3	11.5	12.6	12.3	45.7	11.4	12.6	9.3

(Option B continues on the following page)

(Option B, question 6 continued)

	A	B	C	D	E	F	G	H	I
27	Staff	76.8	79.3	96.3	81.2	333.6	83.4	96.3	76.8
28	Total	86.0	90.8	108.9	93.6	379.3	94.8	108.9	86.0
29									
30	Total costs	262.7	252.3	330.2	252.3	1097.4	274.4	335.9	225.5
31									
32	Profit	22.2	8.2	25.8	9.4	65.6	16.4	30.7	3.1

(d) Identify the formulas used in the cells:

(i) B30 [1]

(ii) B32 [1]

The names of the departments have been stored in a one-dimensional array, `DEPARTMENT []`. It has been decided to use a number of parallel one-dimensional arrays to store the quarterly figures and the annual totals for each department.

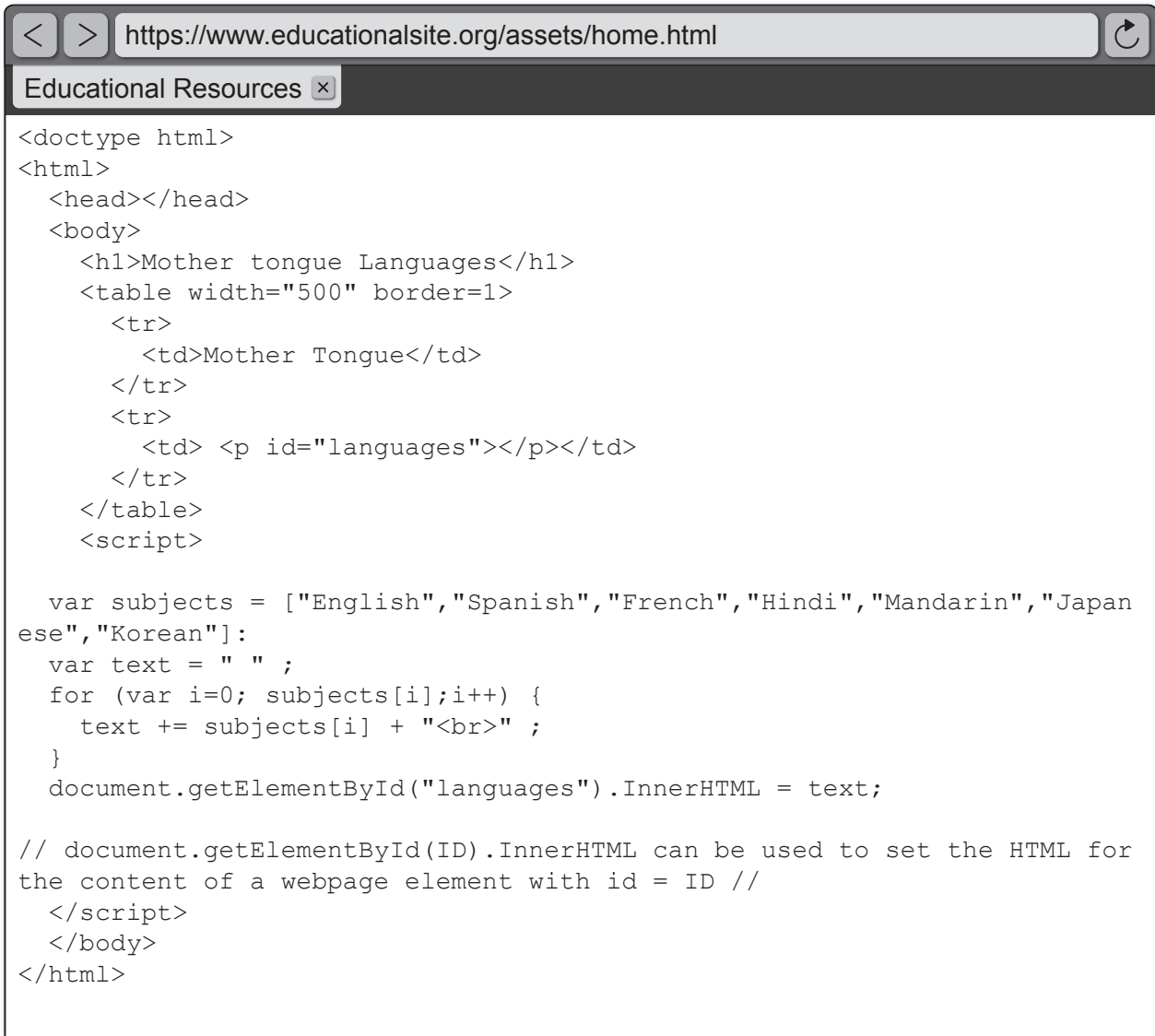
(e) Construct the pseudocode required to enter the data for each department for each separate quarter, calculate the annual totals and store the data into suitably named arrays. [6]

End of Option B

Option C — Web science

- 7. The web browser shown in **Figure 6** includes a feature that enables the user to inspect the source code.

Figure 6: The source code for the web page



- (a) Outline why the URL in **Figure 6** is a “Full URL”. [2]
- (b) Sketch the output of the code in **Figure 6**. [3]
- (c) Outline why the web page in **Figure 6** is a static web page. [2]

(Option C continues on the following page)

(Option C, question 7 continued)

The web page in **Figure 6** uses Javascript elements.

(d) Explain why the support of client-side scripting languages is a key function of web browsers. [3]

(e) Distinguish between a protocol and a standard. [2]

A user wants to access another website and enters its URL into the address bar.

(f) Describe how the domain name service (DNS) enables the user to access the new site. [4]

A user wishes to download a video resource from a web-based host to their smartphone. The site offers a lossy download option and lossless download option. It was recommended that the user uses the lossy compression option for this download.

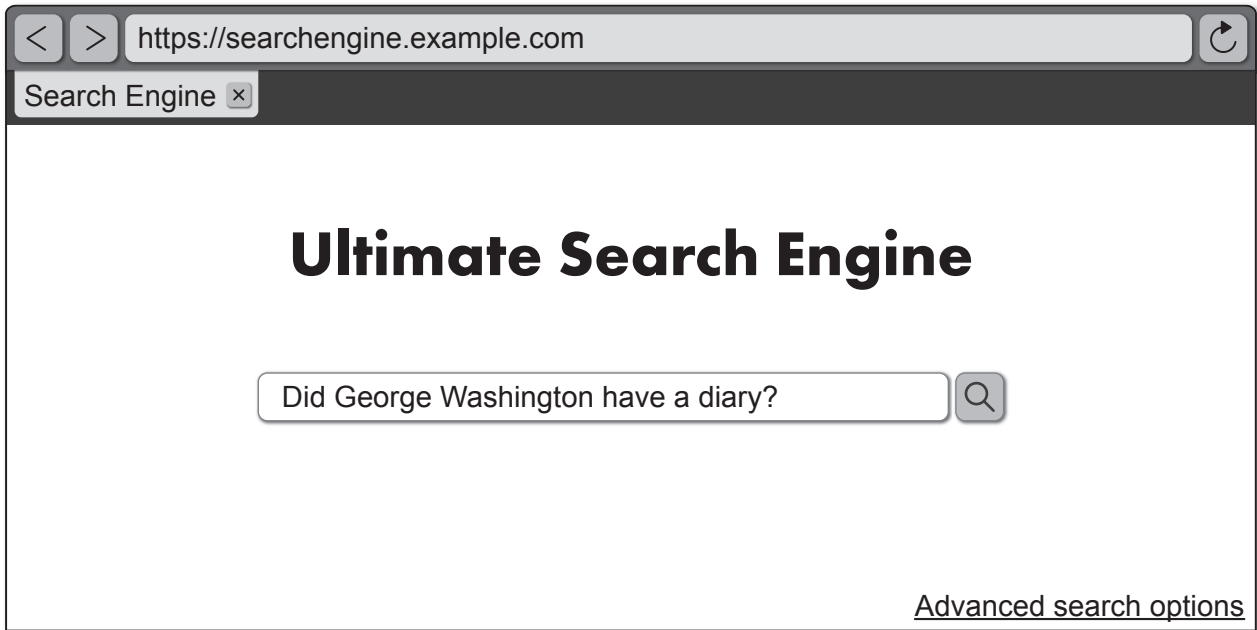
(g) Explain why lossy compression is used in mobile computing. [4]

(Option C continues on the following page)

(Option C continued)

- 8. While working on an assignment task for History of the Americas, Brooke enters a question into a search engine (**Figure 7**).

Figure 7: The Ultimate Search Engine



The search returns 173 000 results in 0.043 seconds.

Another student indicated that Brooke would obtain better results using keywords rather than a search phrase.

- (a) Outline why keywords would be used in a search rather than a phrase.

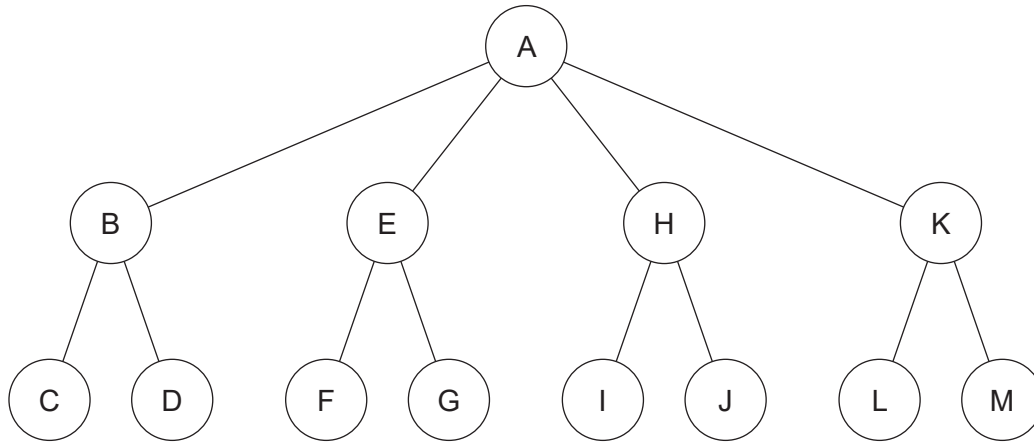
[2]

(Option C continues on the following page)

(Option C, question 8 continued)

Web crawling indexes webpages in the search engine's database (**Figure 8**). The two web crawling methods used are a breadth-first crawl and a depth-first crawl.

Figure 8: Webpages in the search engine's database



(b) In **Figure 8**, A has not been previously visited. State the first **three** webpages visited in a breadth-first search. [1]

(c) Outline **one** reason why search engines use a breadth-first search. [2]

As the web crawler traverses the pages in a website it collects data. This is used to form the metrics data for search rankings.

(d) Identify **two** features of the PageRank algorithm. [2]

Many web developers attempt to optimize the search results for their site.

(e) Explain the impact for DP History students such as Brooke if the web developer uses black hat search engine optimization techniques. [4]

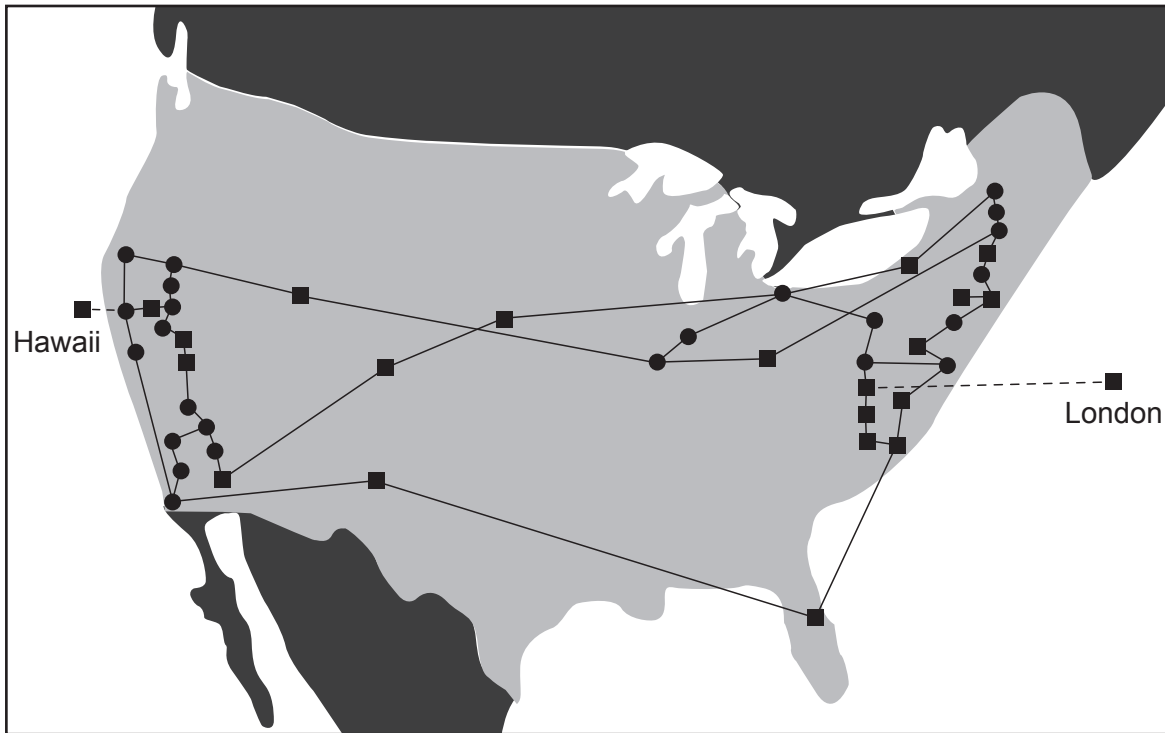
(Option C continues on page 17)

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(Option C continued)

- 9. ARPANET was developed as a project by the American military. It became the technical foundation for the internet. **Figure 9** is a representation of ARPANET in 1974.

Figure 9: The ARPANET network in 1974



- (a) Outline **one** reason why ARPANET was developed as a distributed network. [2]

The original ARPANET used cable networks within the US. When linking to Hawaii and the United Kingdom it used a satellite link. The network consisted of connected mainframe computers hosting servers that had a number of connected terminals (clients).

- (b) Outline **one** advantage of using a client-server architecture. [2]

The nature of computing has evolved from client-server architecture to peer-2-peer and cloud computing.

- (c) Compare peer-2-peer **and** cloud computing. [4]

Decentralization of the web is partly a result of open standards, interoperability and distributed networks.

- (d) To what extent have open standards **and** interoperability supported the decentralization of the web? [6]

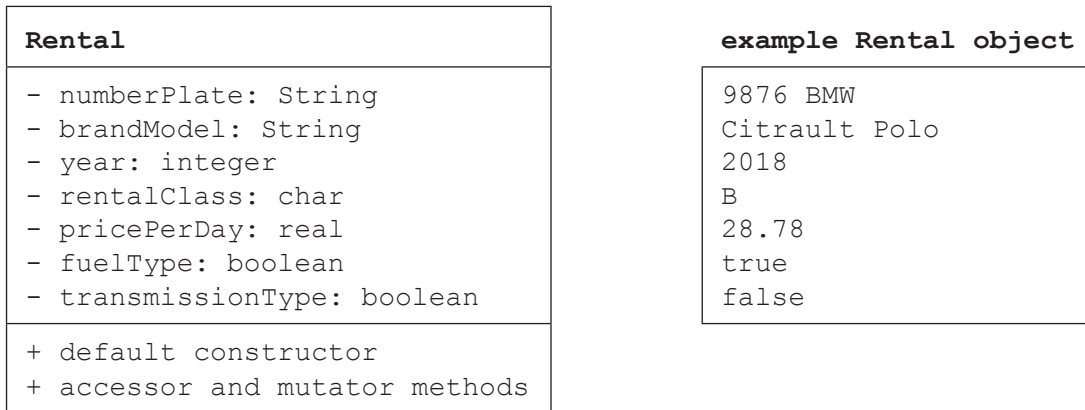
End of Option C

Option D — Object-oriented programming

10. A car rental company has offices in cities in Spain and Portugal. It manages its cars as a large, unsorted collection of rental objects that is accessed by a Java program.

The following UML diagram describes the current main `Rental` class. Fuel type and transmission type were chosen to be Boolean because they have two choices: petrol or diesel for fuel type, and manual or automatic for transmission type.

The brand and the model of the car are stored together as one string `brandModel`. Typically the company has many cars of the same brand and model.



- (a) Outline the general nature of an object. [2]
- (b) State **one** mutator method to be included in the class `Rental`. [1]
- (c) Construct the code for the accessor method `getBrandModel()`. [3]
- (d) Outline **one** purpose of a default constructor. [2]

The company is buying new electric cars and hybrid cars.

- (e) Outline **one** change that needs to be made to class `Rental` due to this development. [2]

Based on this `Rental` class, the program defines several other classes: `Car`, `Bus` and `Van`, each with their own characteristics. For example, the class `Car` adds the attribute `numberOfDoors` to the class `Rental`.

- (f) State the relationship between `Rental` and `Car`. [1]
- (g) Construct the code for the class `Car` without having to duplicate all the attributes and methods from the class `Rental`. The default constructor of the class `Rental` should be overridden to also assign the value 4 to `numberOfDoors`. No other constructors are required. [3]

(Option D continues on the following page)

(Option D continued)

- 11. (a) Identify the OOP feature that was used to declare the `Car` class. [1]
- (b) Explain the benefits of the feature identified in **part (a)**. [3]
- (c) Identify the **two** other features of OOP. [2]
- (d) Describe **one** advantage of modularity in program development. [2]

12. All `Car` objects have been read into a large unsorted array called `allCars`.

A method is needed to show customers the range of available cars.

This method should take the array `allCars` as a parameter and select `Car` objects from `allCars` so that every available `brandModel` is presented only once.

You may assume that there are never more than 100 different types of cars (as identified by the variable `brandModel`).

- (a) Define the term *parameter variable*. [2]
- (b) Construct the code for the method `findBrandModels()` that will take the array `allCars` as a parameter. It must return a `Car` array that contains every `brandModel` that is available without duplication. [8]

A customer wants to see which different types of cars are available. The criteria are it must be a petrol car with automatic transmission and cost less than 35 euros per day.

- (c) Without writing code, outline the steps needed for a method to perform this query and present the results to the customer. [5]

13. The car rental company also has a database of customers. For each customer it stores an object with personal data such as their ID, name and address.

This `Customer` object includes the history of the cars they have rented and the car they are currently renting (if any).

- (a) Draw the relationship between `Customer` and `Car` objects. [1]

A suggestion has been made to modify the `Rental` class to include `customerID`. The intention is to make it easier to find the customer who has a certain car.

- (b) Describe in terms of dependencies why this suggestion is inappropriate. [2]
- (c) Explain the ethical obligations for programmers when developing a customer database. [5]

End of Option D

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References:

9. Semaforo GMS. Arpanet in the 1970s.png. https://commons.wikimedia.org/wiki/File:Arpanet_in_the_1970s.png. Licensed under CC BY-SA 4.0 DEED <https://creativecommons.org/licenses/by-sa/4.0/deed.en>. Image adapted.