Diploma Programme
Programme du diplôme
Programa del Diploma

Computer science
Standard level
Paper 2

13 November 2025

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 – 12

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22 pages

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Option A — Databases

1. A dental clinic employs dentists and nurses.

- Many dentists work at a single dental clinic.
- Many nurses work at a single dental clinic.
- A dentist can work with many nurses.
- A nurse can assist many dentists.

(a) Construct an entity-relationship diagram (ERD) that shows the relationships between clinic, dentist, and nurse. [3]

A dentist adds comments to the clinic's database using an electronic device rather than using a paper-based medical record.

(b) Explain **two** advantages of storing medical notes in a database. [6]

A database transaction occurs when a patient pays their bill. To maintain data consistency and integrity during the transaction, the database goes through several states.

(c) Describe the change in database states when a transaction is updated. [3]

Log files are stored prior to database updates. If the database crashes, the log files are used to recover the database.

(d) Describe the steps used in log recovery when a database crashes. [3]

(Option A continues on the following page)

(Option A continued)

2. When a patient visits the dental clinic, a dentist may carry out a number of tests. Each record of a test is placed in a TEST table:

```
TEST (PatientID, NurseID, DateTime, TestType, PatientName, Notes)
```

This table uses a composite primary key of PatientID, NurseID, and DateTime.

(a) Outline why DateTime has been included as part of the composite primary key. [2]

(b) Outline why the TEST table is not in second normal form (2NF). [2]

The TEST table is shown in **Figure 1**, and the NURSE table is shown in **Figure 2**.

Figure 1: The TEST table

PatientID	NurseID	DateTime	TestType	PatientName	Notes
5	BM2385	2024/11/17 09:05	Oral X-ray	Simon Moore	Tooth fracture
54	JF2227	2024/11/17 09:05	Dental scan	Ciara Alinac	Implant planning
78	BM2385	2024/11/19 09:45	Oral X-ray	Scottie Ngatai	Tooth decay
23	JF2227	2024/11/19 09:35	Dental scan	William Hartley	Assessment
30	AS2590	2024/11/19 10:15	Oral X-ray	Emma Lee	Impacted teeth
29	JF2227	2024/11/20 11:20	Dental scan	Lena Lee	Assessment

Figure 2: The NURSE table

NurseID	NurseName	Nationality	PhoneNumber	StartDate
BM2385	Billy McCoy	Scottish	0102930308	2022/04/17
AS2590	Anya Svetlana	Russian	0102940209	2023/01/29
JF2227	James Fernley	English	0102839305	2019/06/18

(c) State the output from the following query:

```
SELECT PatientName FROM TEST
WHERE TestType = "Oral X-ray"
AND NurseID = "BM2385";
```
[2]

(d) Construct a query to find patients who had a test carried out by the nurse Anya Svetlana at any time on 19 November 2024. [4]

(Option A continues on the following page)

(Option A, question 2 continued)

Figure 3 is an extract showing patients' appointments with dentists and the cost of their treatments.

Figure 3: Extract showing patients' appointments with dentists and the cost of their treatments

PatientID	PatientName	Dentist	Specialties	VisitDateTime	Treatment	Cost
1	Zixin Yang	Dr Kim	Orthodontics	2024/12/01 09:00	Braces fitting	300
		Dr Kim	Orthodontics	2024/12/08 09:30	Braces adjust	100
2	Charlie Algie	Dr Ali	Periodontics	2024/11/29 10:00	Gum cleaning	180
		Dr Ali	Periodontics	2024/11/30 10:00	Gum surgery	500
3	Eve Armstrong	Dr Ito	General	2024/09/01 14:00	Cavity filling	120
		Dr Ito	General	2024/09/02 14:00	Whitening	250
4	Chan Oh	Dr Ito	General	2024/09/05 11:00	Cavity filling	120
		Dr Ito	General	2024/09/12 11:30	Cleaning	90
5	Simon Moore	Dr Kim	Orthodontics	2024/12/02 10:00	Braces fitting	300
		Dr Kim	Orthodontics	2024/12/09 11:00	Braces adjust	100

(e) Construct the database in 3rd normal form (3NF) for the entities shown in **Figure 3**.

You should use the following notation:

`TABLE (KEY, FIELD1, FIELD2,…)` [5]

(Option A continues on page 7)

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(Option A continued)

3. The database administrator is responsible for maintaining data integrity once the dental clinic's database is operational.

(a) Outline **one** strategy for maintaining data integrity. [2]

The dental clinic is looking to develop an integrated database system.

(b) Outline what an integrated database system is. [2]

The end-user can interact with the database through a visual query.

(c) Describe how the end-user might use a visual query to filter data in the database. [3]

Dental clinics can use data mining to predict outbreaks of infectious oral diseases.

(d) Describe how data mining could be used to predict infectious oral diseases. [3]

The dental clinic is planning to allow insurance companies to view its database records.

(e) Discuss the advantages **and** disadvantages for the dental clinic of allowing insurance companies to view its records. [5]

End of Option A

Option B — Modelling and simulation

4. Ten children play a game in which all of them or none of them win a prize. The rules of the game are as follows:

- 10 children are assigned a unique number from 0 to 9.
- A cupboard contains 10 boxes, each numbered from 0 to 9.
- 10 sheets of paper are numbered from 0 to 9.
- One piece of paper is put into each box in random order (see **Figure 4**).

Figure 4: 10 boxes, each containing a sheet of paper with a number from 0 to 9

Box	0	1	2	3	4	5	6	7	8	9
Paper	9	8	2	1	7	6	4	3	5	0

Each child is allowed to open 5 boxes to look for their own number. You can assume they will not open the same box twice.

Child number 0 goes first and opens 5 of the 10 boxes.

(a) (i) State the probability of child 0 finding their number in the 5 boxes they opened.

Your answer can be a formula, fraction, or decimal. [1]

(ii) State the probability of all 10 children finding their number.

Your answer can be a formula, fraction, or decimal. [1]

The children all get a prize if all 10 of them find their number within 5 attempts. They use the follow-the-number strategy:

1: Each child first opens the box labelled with their own number.
2: If this box contains their number, they are successful.
3: If unsuccessful, the child opens the box shown on the piece of paper.
4: The child repeats steps 2 to 3 until 5 boxes are opened.

Example 1: Child 0 opens box 0, seeing 9 on the paper. They then open box 9 and see their number. They are successful.

Example 2: Child 1 opens box 1, seeing 8 on the paper. They then open box 8, seeing 5 on the paper. Then they open box 5, then box 6, then box 4. They are not successful.

(b) State the order sequence for child 3, who opens box 3 in **Figure 4**. [1]

(Option B continues on the following page)

(Option B, question 4 continued)

A one-dimensional Boolean array, `CHILDREN`, is created and initialized so that all elements are `False`.

A one-dimensional integer array, `BOX`, is created and initialized so that `BOX` contains `0`, `1`, `2`, `3`, `4`, `5`, `6`, `7`, `8`, `9`.

A function, `random.shuffle(BOX)`, shuffles the `BOX` array randomly to change the sequence.

For example, the new sequence might be: `9`, `8`, `2`, `1`, `7`, `6`, `4`, `3`, `5`, `0`.

Thus, `BOX[5] = 6`

The children use the follow-the-number strategy shown previously.

Each time a child is successful, the corresponding element in the array `CHILDREN` is set to `True`. If a child is unsuccessful, the corresponding element in the array `CHILDREN` is unchanged.

(c) Outline **two** reasons why this problem would be difficult to simulate using a spreadsheet. [4]

(d) Construct an algorithm in pseudocode that uses the follow-the-number strategy before outputting each element in the array `CHILDREN`. [6]

If all 10 cells in the `CHILDREN` array are set to `True`, the children all win a prize.

To calculate the percentage of times all the children will win a prize, the pseudocode algorithm in part (d) needs to be run 10 000 times.

(e) Construct an algorithm in pseudocode that outputs, as a percentage, the number of times the children all win a prize. [4]

(Option B continues on page 11)

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(Option B continued)

5. Computer models play a crucial role in developing self-driving cars.

(a) Identify **one** system that can be modelled. [1]

In addition to computer models, the development of self-driving cars relies heavily on simulations to test and refine their decision-making algorithms.

(b) Identify **one** traffic condition variable for a self-driving simulation. [1]

Traffic condition is a suitable grouping for collections of data items relating to self-driving cars.

(c) Outline **two** other suitable groupings for data items relating to self-driving cars. [4]

A mathematical model and a computer simulation have been developed to represent self-driving cars in real-world traffic conditions.

(d) Compare and contrast the use of a mathematical model and a simulation. [4]

Test-case scenarios are employed to evaluate a simulation. For example, self-driving cars can be tested for sensor failure.

(e) Outline **one** test-case scenario for sensor failure. [2]

Organizations and drivers have voiced concerns about the use of a simulation to test self-driving cars.

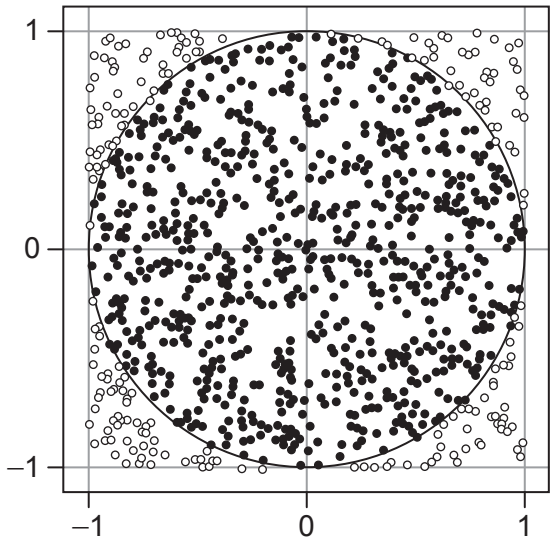
(f) Explain **one** concern about simulating self-driving cars in real-world scenarios. [4]

(Option B continues on the following page)

(Option B continued)

6. The Monte Carlo estimation of pi (π) is achieved by randomly generating points within a square and counting how many fall within an inscribed circle (see **Figure 5**).

Figure 5: 2D visualization of the Monte Carlo estimation of π



(a) Outline the appropriateness of using a 2D visualization for the Monte Carlo estimation of π. [2]

A spreadsheet model can be created to simulate the Monte Carlo method for the estimation of π.

The `=RAND()` spreadsheet function is used in columns **x-cord** and **y-cord** (see **Figure 6**) to generate a random decimal between 0 and 1.

The **distance** column uses Pythagoras' theorem to calculate distance, where *a* is **x-cord** and *b* is **y-cord**:

$$c = \sqrt{a^2 + b^2}$$

The **In or Out** column is determined using an IF statement. When distance is less than 1, "In" is shown. When distance is 1 or more, "Out" is shown.

(Option B continues on the following page)

(Option B, question 6 continued)

Figure 6: The four columns needed in the simulation of the Monte Carlo method for the estimation of π

	A	B	C	D	E
1	x-cord	y-cord	distance	In or Out	
2	0.9709594	0.03075972	0.97144651	In	
3	0.47929644	0.46729567	0.66939549	In	

(b) (i) State a formula to calculate the distance for cell C2. [1]

(ii) State a formula to show In or Out for cell D2. [1]

The formulae in row 2, columns A, B, C, and D, are automatically filled down to row 5001.

A range of 5000 numbers will be sufficient to give a good approximation of π.

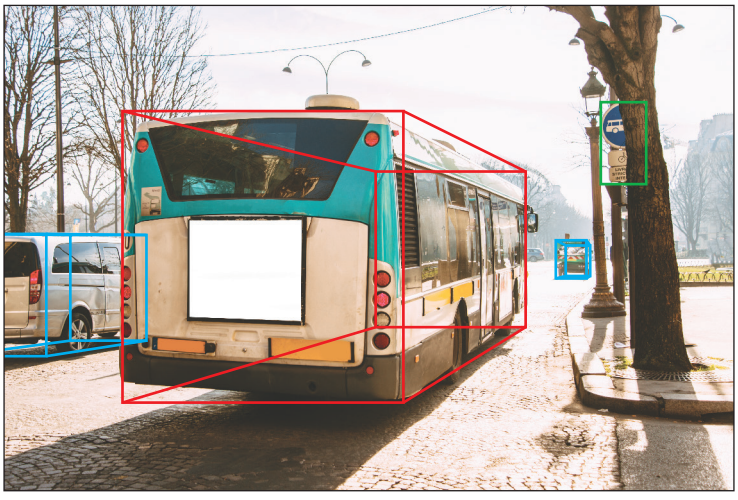
To give an approximation for π, a formula should be entered in cell E2.

The formula will calculate the ratio of points inside the circle (the number of "In" occurrences) relative to the total points (total number of rows) and multiply the result by 4.

(c) State a formula to be entered in cell E2. [3]

Bounding boxes in the context of self-driving cars are 3D geometric shapes encapsulating surrounding objects that are memory and processor intensive (see **Figure 7**).

Figure 7: 3D visualization of a bounding box



(d) Evaluate the processing power **and** memory requirements needed to calculate the 3D bounding boxes for self-driving cars. [5]

End of Option B

Option C — Web science

7. *Hardware4Hotels* is a company that provides services to hotels, such as carrying out electrical repairs, decorating, and plumbing.

The URL for the company's website is http://hardware4hotels.example.com

(a) (i) State the protocol in the company's website URL. [1]

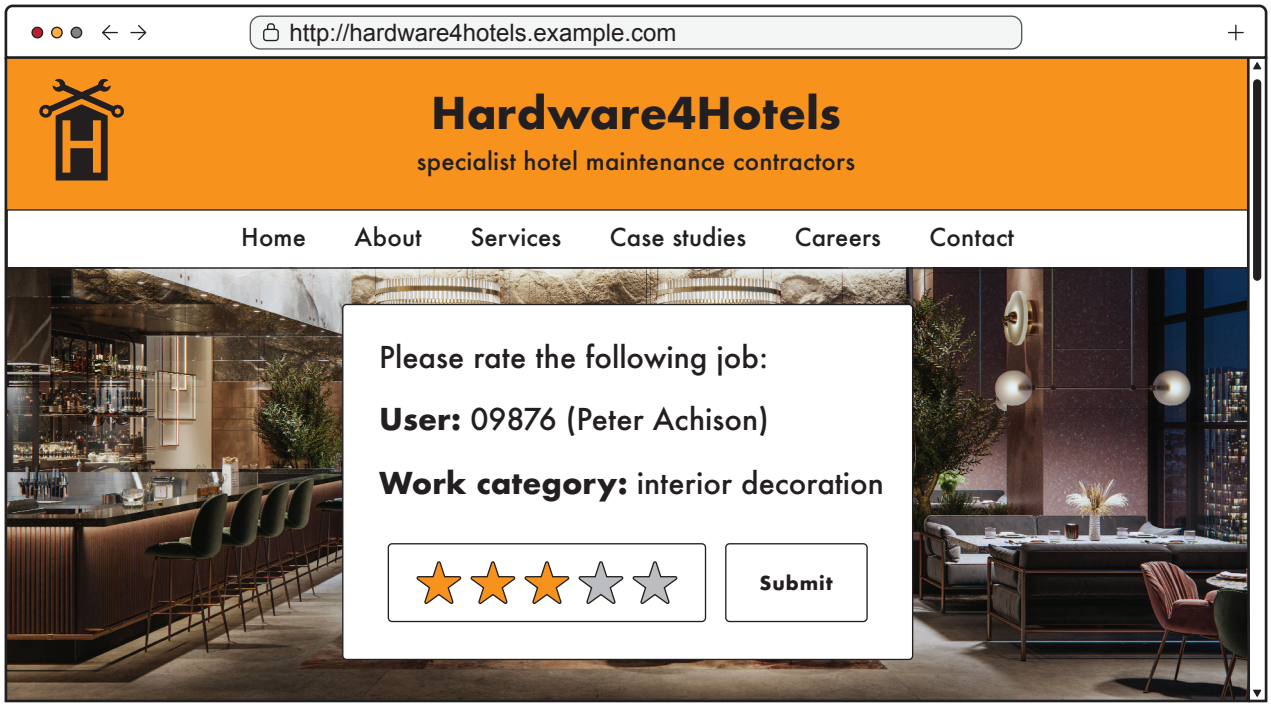
(ii) State the domain name in the company's website URL. [1]

(b) Outline the importance of protocols when browsing websites. [2]

(c) Identify **two** components of a webpage. [2]

The website for *Hardware4Hotels* has been designed so it can receive feedback from its customers. After the work has been completed, the customer is asked to submit a score from 1 to 5 for the service provided (see **Figure 8**).

Figure 8: The *Hardware4Hotels* feedback webpage



(d) Describe the role of the common gateway interface (CGI) on the *Hardware4Hotels* website. [2]

(Option C continues on the following page)

(Option C, question 7 continued)

The following is part of the code that is run on the server when a customer (the user) submits a rating.

```
<?php
$work_category = $_POST["work_category"];
$rating = $_POST["rating"];
$conn = mysqli_connect("localhost", $username, $password, "sales");
$sql = "SELECT AVG(rating) as averageRating FROM ratings WHERE work_
category = '$work_category'";
$result = mysqli_query($conn, $sql);
$row = mysqli_fetch_assoc($result);
$averageRating = $row["averageRating"];
$sql = "INSERT INTO ratings (work_category, rating) VALUES ('$work_
category', $rating)";
mysqli_query($conn, $sql);
if ($rating >= $averageRating) {
    echo "Thank you for the good review.";
} else {
    echo "Sorry, we will try to do better next time.";
}
mysqli_close($conn);
?>
```

(e) (i) Describe the processing that takes place when this code is executed. [4]

(ii) Outline **one** advantage of executing this code on a server rather than in the browser. [3]

(Option C continues on the following page)

(Option C continued)

8. MYP students at *One2Seven Academy* used a search engine to find information about their school.

Figure 9 shows the outcome of their search.

Figure 9: Number of results from a search for *One2Seven Academy*

(a) Outline why **Figure 9** shows that there are 248 000 results when there are actually fewer web pages about *One2Seven Academy*. [2]

(b) Describe **one** principle used by the PageRank algorithm as it searches for web pages about *One2Seven Academy*. [3]

The webmaster at *One2Seven Academy* is considering increasing the number of meta tags included in the website.

(c) Identify **two other** ways in which the webmaster could improve the ranking of the *One2Seven Academy* website. [2]

(d) Explain the relationship between the data in a meta tag and how it is accessed by a web crawler. [3]

(e) Discuss whether the webmaster of *One2Seven Academy* should use white hat search engine optimization techniques or black hat search engine optimization techniques. [5]

(f) Identify **two** challenges that search engines face as the web continues to evolve. [2]

(Option C continues on the following page)

(Option C continued)

9. Recent developments in computing technologies have led to the growth of mobile computing and ubiquitous computing.

(a) Distinguish between mobile computing and ubiquitous computing. [2]

(b) Explain **one** reason for the growth in mobile computing. [3]

Mobile computing and ubiquitous computing both use distributed networks and cloud computing.

(c) Explain how the use of distributed networks and cloud computing has led to a decentralization of the web. [3]

Companies can use private clouds and public clouds for the storage of their data.

(d) Evaluate the use of private clouds and public clouds for the storage of a company's data. [5]

End of Option C

Option D — Object-oriented programming

10. A law firm has 20 lawyers. They can be categorized into three groups: civil lawyers, criminal lawyers, and company lawyers.

A lawyer can have a maximum of 15 cases at a time.

The following shows part of the code for the `Lawyer` class, which keeps details of a lawyer:

```
public class Lawyer
{
    private int lawyerID;       // id of the lawyer
    private String lawyerName;
    private String lawyerType;  // category of lawyer
    private int lawyerRank;     // 0 or 1, default is 0
    private int casesWon;       // total number of cases won by the lawyer
    private Case lawyerCases[] = new Case[15]; // lawyer's array of cases

    public Lawyer(int lawyerID, String lawyerName, String lawyerType,
Case[] lawyerCases)
    {
        this.lawyerID = lawyerID;
        this.lawyerName = lawyerName;
        this.lawyerType = lawyerType;
        this.lawyerRank = 0;
        this.casesWon = 0;
        this.lawyerCases = lawyerCases;
    }

    public String getlawyerName()
    {
        return lawyerName;
    }

    public String getlawyerType()
    {
        return lawyerType;
    }

    public int getlawyerRank()
    {
        return lawyerRank;
    }

    public void setlawyerRank(int lawyerRank)
    {
        this.lawyerRank = lawyerRank;
    }

    // all accessor and mutator methods are present but not shown

} // end of Lawyer class
```

(Option D continues on the following page)

(Option D, question 10 continued)

The following shows part of the code for the `Case` class, which keeps details of a case:

```
public class Case
{
    private int caseId;        // unique id of the case
    private String caseClient; // name of the client
    private String caseTitle;  // e.g. 'property dispute', 'tax evasion' etc
    private int daysFromStart; // number of days elapsed from start of case
    private char judgmentGiven; // 'N'=no, 'F'=favorable, 'A'=against
    private String caseStatus;  // open/ won/ lost

    public Case(int caseID, String caseClient, String casesTitle)
    {
        this.caseId = caseId;
        this.caseClient = caseClient;
        this.casesTitle = casesTitle;
        this.daysFromStart = 0;
        this.judgmentGiven = 'N';
        this.caseStatus = "open";
    }

    public void setCaseStatus(String caseStatus)
    {
        this.caseStatus = caseStatus;
    }

    // all accessor and mutator methods are present but not shown

    public void changeCaseStatus(char judgmentGiven)
    {
        /*Code missing*/
    }

} // end of Case class
```

(Option D continues on the following page)

(Option D, question 10 continued)

The `LawFirmManagement` class has a main method and other methods to generate the information required. The following shows part of the code for the `LawFirmManagement` class:

```
public class LawFirmManagement
{
    private static Lawyer[] allLawyers = new Lawyer[20];
    // array of lawyers

    private static TraineeLawyer[] allTrainees = new
TraineeLawyer[30]; // array of lawyer trainees

    public static void main(String []args)
    {
        /*Code missing*/
    }

    public static void displayLawyerNames()
    {
        /*Code missing*/
    }

    public static void updateLawyerRank(int[][]casesWon)
    {
        /*Code missing*/
    }

} // end of LawFirmManagement class
```

(a) State the purpose of a constructor method. [1]

(b) Describe how the `changeCaseStatus(char judgmentGiven)` method given in the `Case` class would change the case status. [2]

(c) Construct the method `displayLawyerNames()` in the `LawFirmManagement` class.

The method should display the names of all civil lawyers who have won more than 30 cases. [4]

(d) (i) State the purpose of a return statement. [1]

If the number of days since the start of a case is more than 45 and no judgment has been given, it is considered a delayed case. Assume that a method exists that updates days elapsed.

(ii) Construct the method signature for `countDelayedCases` in which the method takes a lawyer's ID as a parameter and returns the total number of delayed cases that the lawyer has. [2]

(iii) Construct the complete code for the method `countDelayedCases` constructed in part (d)(ii). [5]

(Option D continues on the following page)

(Option D continued)

11. The law firm employs trainee lawyers who work under senior lawyers for one year and then sit an examination. On successful completion, they become full lawyers.

The `TraineeLawyer` class has been created. A trainee lawyer is a lawyer with two additional attributes: joining date and exam status.

(a) (i) Identify a suitable data type for each additional attribute in the `TraineeLawyer` class. [2]

(ii) Construct a detailed class diagram including attributes, methods, and relationship.

The diagram must include the `Lawyer` class **and** the `TraineeLawyer` class. [4]

(b) (i) State the relationship between the `TraineeLawyer` class and the `Lawyer` class. [1]

(ii) State the relationship between the `Lawyer` class and the `Case` class. [1]

(iii) Describe the difference between the two relationships stated in part (b)(i) and part (b)(ii). [4]

(c) Outline what is meant by the term encapsulation. [2]

(d) Define the term *parent object*. [1]

(Option D continues on the following page)

(Option D continued)

12. (a) (i) The following code fragment has been written to count and output the number of civil lawyers and company lawyers that the law firm has:

```
int x = 0;
int countA = 0;

while (x > 20)
{
    if(allLawyers[x].getLawyerType().equals("civil"))
        countA++;

    else if(allLawyers[x].getLawyerType().equals("company"))
        countB++;
}

System.out.println("civil: "+ countA + "company: " + countB);
```

Identify **three** reasons why this code does not work as expected. [3]

(ii) Construct a method, `displayClientName()`, to display all client names of company lawyers where a judgment has been passed on the case. Assume that there will always be at least one such client. The method must:

- search the `allLaywers[]` array for `lawyerType` is "company"
- search the `lawyerCases[]` array for `judgmentGiven` is "A"
- output the client's name. [7]

The law firm is considering the use of open source software as part of its software development process.

(b) Discuss the impact of the open source movement on the software industry. [5]

End of Option D

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References:

Figure 5 Copyright © 2017–2022 Mark Galassi, Leina Gries, Sophia Mulholland, Almond Heil. https://www.galassi.org/mark/markgalassi-documentation-builds/small-courses-html/optimal-stopping/optimal-stopping.html#fig-circle-monte-carlo. This work is licensed under the CC BY-SA 4.0 International License https://creativecommons.org/licenses/by-sa/4.0/. Source adapted.

Figure 7 MarioGuti, 2017. *Paris bus with billboards - stock photo.* [image online] Available at: https://www.gettyimages.co.uk/detail/photo/paris-bus-with-billboards-royalty-free-image/640267632 [Accessed 25 September 2024]. Source adapted.

Figure 8 alvarez, 2020. *Luxury restaurant interior at night - stock photo*. [image online] Available at: https://www.gettyimages.co.uk/detail/photo/luxury-restaurant-interior-at-night-royalty-free-image/1248298359. Source adapted.