![IB Diploma Programme logo] Diploma Programme
Programme du diplôme
Programa del Diploma

Computer science
Higher level
Paper 1

Thursday 5 May 2022 (afternoon)

2 hours 10 minutes

Instructions to candidates

- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer all questions.
- The maximum mark for this examination paper is **[100 marks]**.

9 pages

International Baccalaureate
Baccalauréat International
Bachillerato Internacional

Section A

Answer **all** questions

1. State **two** compatibility issues that may arise when international businesses merge. [2]

2. Outline **one** reason why accurate user documentation is necessary for a system. [2]

3. Identify **two** differences between a wide area network (WAN) and a local area network (LAN). [2]

4. Outline the reason for compression when transmitting data. [2]

5. Outline the need for a translation process from high level language to machine code. [2]

6. Draw the truth table for the following logic circuit. [4]
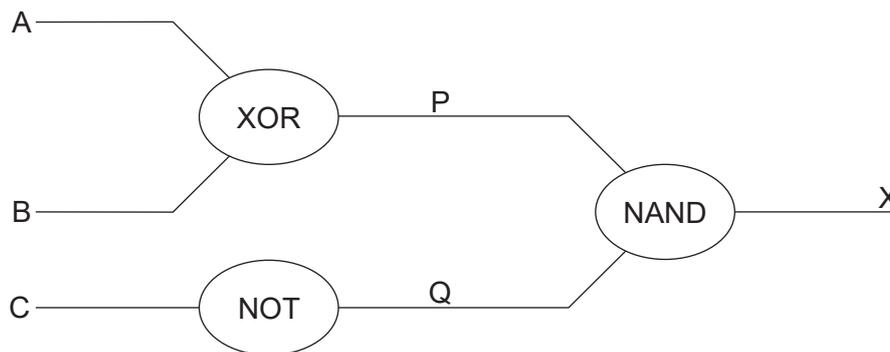
7. Calculate, showing your working in each case:

    (a) the binary (base 2) value of the denary (base 10) number: 105 [2]

    (b) the hexadecimal (base 16) value of the denary (base 10) number: 200 [2]

8. State **three** operating system resource management techniques. [3]

9. (a) Identify **one** characteristic of a queue. [1]

    (b) Identify **one** application of a queue. [1]

10. Define the term child in relation to a binary tree. [2]

Section B

Answer **all** questions

11. A business's computer system needs to be updated.

    (a)   (i)   Identify **one** stakeholder to be considered when planning the new system. [1]

        (ii)   Outline **one** consequence of not including all stakeholders in the design of the new system. [2]

    (b)   Describe **two** appropriate techniques to gather the information needed to find a suitable solution for the updated system. [4]

    (c)   Outline **one** reason testing should take place at every stage of the development process. [2]

The new system is now ready for implementation.

    (d)   Evaluate **two** methods the business could use to implement the new system. Include the benefits and drawbacks of each. [6]

12. A teacher would like a simple program to store the names, marks and grades of students in a set of three parallel one-dimensional arrays called `NAME[]`, `MARK[]` and `GRADE[]`.

The grade boundaries for the individual grades are shown below:

Mark	Grade
80 and above	Distinction
60 and above	Merit
40 and above	Pass
Below 40	Fail

The class has 30 students.

    (a)   Identify **two** components in a conditional statement. [2]

    (b)   Construct an algorithm using pseudocode to take the marks that have been stored in `MARK[]`, convert them into the appropriate grade and store the calculated grades in `GRADE[]`. [5]

    (c)   Outline how the name, mark and grade in the three arrays correspond to the same student. [2]

    (d)   Construct an algorithm using pseudocode to output the names and grades of all students who achieve a grade of Merit or Distinction. [3]

    (e)   Explain how you would change your algorithm in **part (d)** to allow a user to choose a grade and output the names and marks of the students who have achieved this grade. [3]

Turn over

13. Cars have many automated features to improve the driving experience. One example is the use of headlights that automatically switch on and off.

(a) State **one** input device used by the automated headlights. [1]

Some cars have adaptive cruise control. This uses RADAR technology and a processor to ensure the car stays the same distance away from the car in front.

(b) Explain how the interaction between the inputs, processing and the outputs of the feedback loop ensure the car stays the same distance away from the car in front. [6]

A system with many functions operating independently could be managed using either centralized or decentralized processing.

(c) Discuss the use of centralized and decentralized processing in the context of control systems such as those involved in the operation of motor vehicles [5]

As vehicles become fully autonomous (self-driving), ethical considerations must be taken into account when designing software.

(d) Explain **one** ethical concern that must be considered in the development of autonomous vehicles. [3]

14. The flowchart on **page 6** represents an algorithm that allows a user to enter the number of sides, length of side and apothem (see diagram below) for a regular polygon. It then calculates and outputs the area and perimeter of this shape.

Worked example: a regular hexagon

Number of sides $= 6$

Length of side $= 10\,\text{cm}$

Apothem $= 8.66\,\text{cm}$

Perimeter $=$ Number of sides $\times$ Length of side

$$= 6 \times 10$$

$$= 60\,\text{cm}$$

$$\text{Area} = \frac{\text{Perimeter} \times \text{Apothem}}{2}$$

$$= \frac{60 \times 8.66}{2}$$

$$= 259.8\,\text{cm}^2$$

A regular hexagon

Apothem 8.66 cm

10 cm

(This question continues on the following page)

(Question 14 continued)
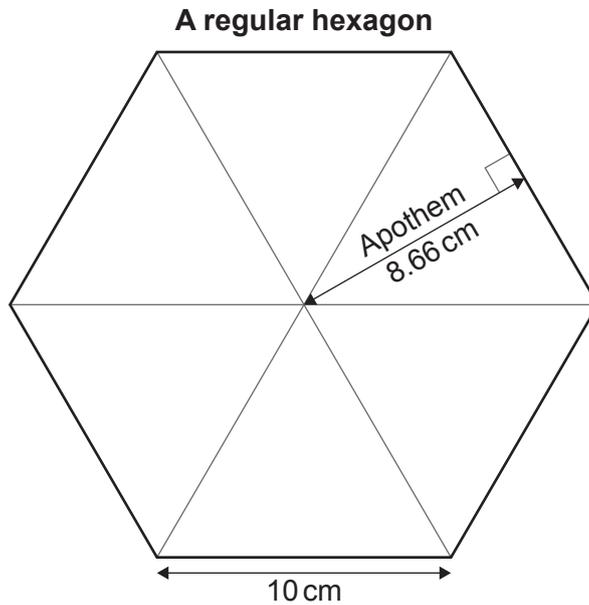
```
                          ╭──────────────╮
                          │    START     │
                          ╰──────┬───────╯
                                 │
                    ╱────────────▼────────────╲
                   ╱  output "Enter the number  ╲
                  ╱    of sides for your shape"   ╲
                  ╲────────────┬─────────────────╱
                                 │
                       ╱─────────▼─────────╲
                      ╱       input          ╲
                      ╲     NUM_SIDES        ╱
                       ╲────────┬──────────╱
                                 │
                    ╱────────────▼────────────╲
                   ╱   output "Enter the length ╲
                  ╱    of each side for your shape"╲
                  ╲────────────┬─────────────────╱
                                 │
                       ╱─────────▼─────────╲
                      ╱       input          ╲
                      ╲     LENGTH_SIDE      ╱
                       ╲────────┬──────────╱
                                 │
                    ╱────────────▼────────────╲
                   ╱  output "Enter the length  ╲
                  ╱   of the apothem for your shape"╲
                  ╲────────────┬─────────────────╱
                                 │
                       ╱─────────▼─────────╲
                      ╱       input          ╲
                      ╲     APOTHEM          ╱
                       ╲────────┬──────────╱
                                 │
                  ┌──────────────▼──────────────┐
                  │ PERIM = NUM_SIDES * LENGTH_SIDE │
                  └──────────────┬──────────────┘
                                 │
                  ┌──────────────▼──────────────┐
                  │  AREA = PERIM * APOTHEM / 2  │
                  └──────────────┬──────────────┘
                                 │
                    ╱────────────▼────────────╲
                   ╱  output "The area of your  ╲
                  ╱      shape is ", AREA         ╲
                  ╲────────────┬─────────────────╱
                                 │
                    ╱────────────▼────────────╲
                   ╱  output "The perimeter of  ╲
                  ╱    your shape is ", PERIM     ╲
                  ╲────────────┬─────────────────╱
                                 │
                          ╭──────▼───────╮
                          │     END      │
                          ╰──────────────╯
```
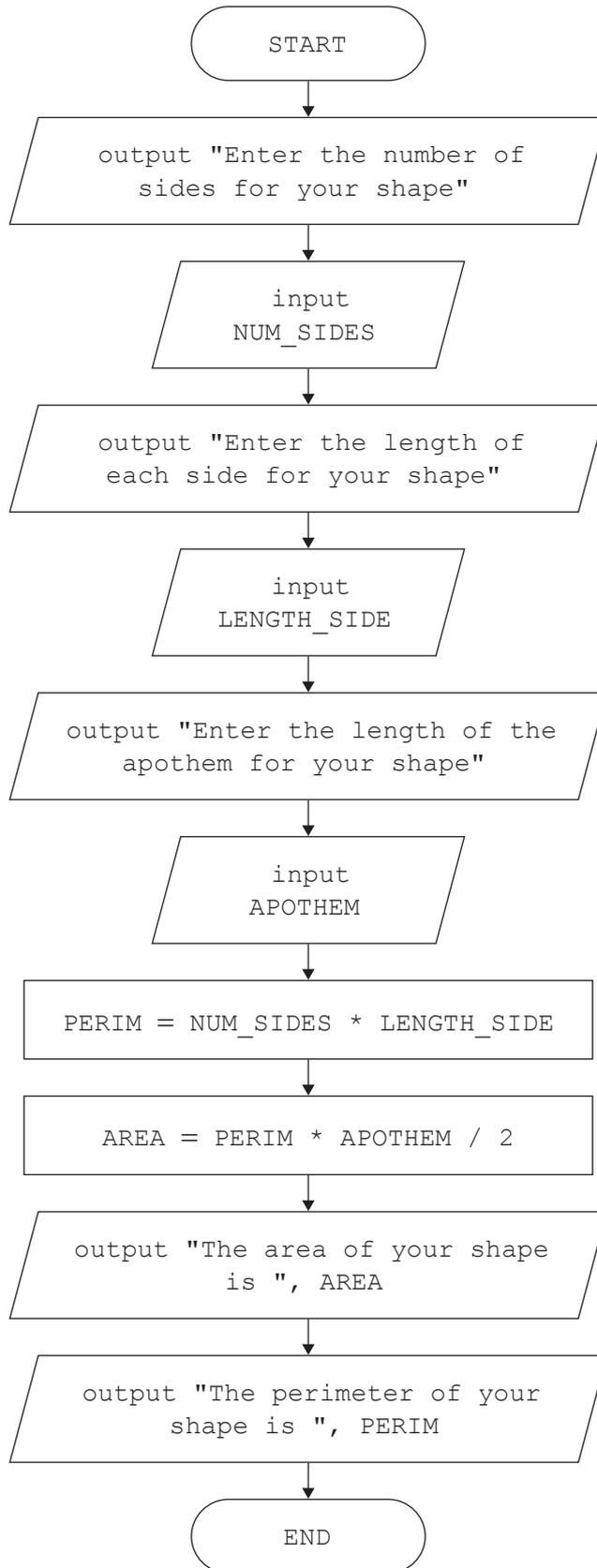
(This question continues on the following page)

(Question 14 continued)

(a) From the flowchart on **page 6**, pseudocode is to be created that will include sub-programs to calculate and return the perimeter and area of the shape.

   (i) Construct pseudocode for the body of the following sub-program to calculate and return the perimeter of the shape.

```
SUB_PERIMETER(NUM_SIDES, LENGTH_SIDE)
    // Pseudocode to be added
end SUB_PERIMETER
```
[2]

   (ii) Construct a similar sub-program to the one in part (i) to calculate and return the area of the shape.

   You must use an appropriate name for the sub-program and appropriate names for the parameters. [4]

   (iii) Construct pseudocode based on the flowchart on **page 6** to collect input from the user, call the sub-programs created in parts (i) and (ii), and output the results. [5]

(b) Without using pseudocode, explain how your algorithms could be altered to **also** find the area and circumference of a circle.

Note:

Area of circle $= \pi r^2$

Circumference of circle $= 2\pi r$ [4]

15. Reverse Polish notation (RPN) is a method used to represent mathematical expressions so they can be evaluated without the need for parentheses.

An expression written in this form is known as postfix notation, whereas an expression written the traditional way is known as infix notation.

For example:

Infix notation: `(8 – 5) * 7`

Postfix notation: `8 5 – 7 *`

Both the infix and postfix expressions have the same result: 21

RPN expressions are evaluated from left to right as follows:
- Each character is checked,
    ◦ if it is a digit, it is pushed onto a stack.
    ◦ if it is a mathematical operator, the last two digits are popped from the stack and evaluated as though the current operator was between them. The result of this operation is then pushed back onto the stack.
- The process is repeated until all the characters in the RPN expression have been used.
- The value left in the stack is the result of the expression.

A collection named RPN already stores an expression formatted in Reverse Polish notation.
The algorithm reads the values from the collection and, using a stack data structure, evaluates it.

```
RPN.resetNext()
loop while RPN.hasNext()
    VALUE = RPN.getNext()
    loop while not (VALUE = "+" or VALUE = "-" or VALUE = "*" or VALUE = "/")
        stack.push(VALUE)
        VALUE = RPN.getNext()
    end loop
    OPERAND2 = stack.pop()
    OPERAND1 = stack.pop()
    if VALUE = "+" then
      NEW_VAL = OPERAND1 + OPERAND2
      stack.push(NEW_VAL)
    end if
    if VALUE = "-" then
      NEW_VAL = OPERAND1 - OPERAND2
      stack.push(NEW_VAL)
    end if
    if VALUE = "*" then
      NEW_VAL = OPERAND1 * OPERAND2
      stack.push(NEW_VAL)
    end if
    if VALUE = "/" then
      NEW_VAL = OPERAND1 / OPERAND2
      stack.push(NEW_VAL)
    end if
end loop
RESULT = stack.pop()
output "The result is: ", RESULT
```

**(This question continues on the following page)**

(Question 15 continued)

(a)   Copy and complete the trace table for the algorithm using the RPN collection data: [6]

5 2 + 25 16 – * 3 /

VALUE	OPERAND2	OPERAND1	NEW_VAL	Output
5				

(b)   Explain why a stack is used in the process of evaluating the expression in the algorithm.   [3]

An alternative data structure in which the expression used in **part (a)** may be stored is a binary tree. If the tree is traversed using postorder tree traversal, the output is formatted in RPN.
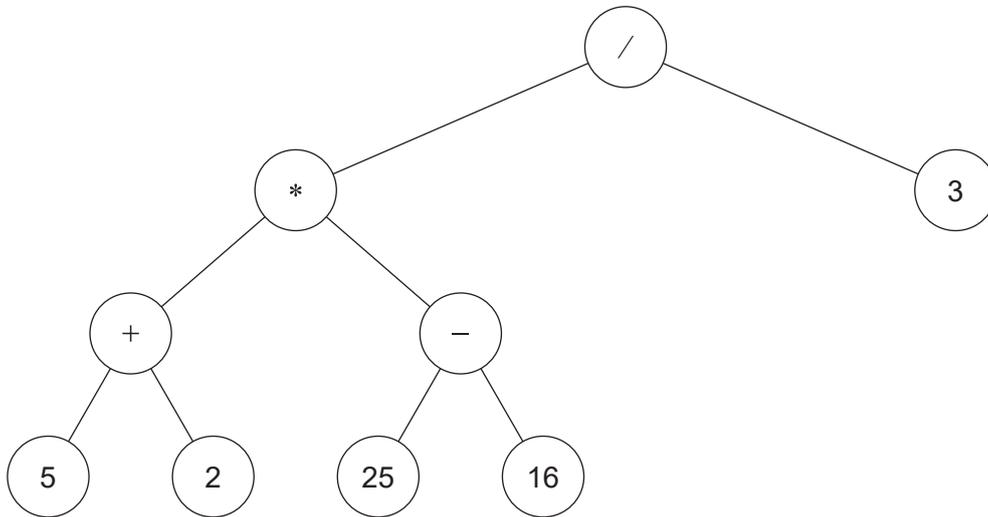
(c)   Outline the steps involved in traversing the given tree using postorder tree traversal.   [4]

(d)   State the output from the given tree using inorder tree traversal.   [2]