CAMEROONIAN ASSOCIATION PROMO MATHS FOR THE PROMOTION OF MATHEMATICS

MISS STEM CAMEROON 2026

SCIENCE • TECHNOLOGY • ENGINEERING • MATHEMATICS

PREPARATION BOOKLET

★ ★ ★ ★ ★

MISS STEM CAMEROON COMPETITION

2026 EDITION

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MISS STEM CAMEROON COMPETITION

2026 Edition

Preparation Booklet

For the Qualification Exam and the Finals

MISS STEM Organizing Committee
Yaoundé, Cameroon

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Important Information

The **MISS STEM CAMEROON** competition is a national competition of excellence designed on the model of a scientific tetrathlon. To claim the prestigious crown, each candidate must demonstrate versatility by competing in four fundamental and complementary fields:

- **Mathematics**: Focused on the four Olympic pillars: Algebra, Number Theory, Geometry, and Combinatorics.
- **Computer Programming**: In Python or C++, to evaluate algorithmic mastery.
- **Technical Drawing**: For spatial vision, projection, and geometric accuracy.
- **Technological Text Analysis**: For engineering culture and critical analysis.

The path to victory consists of two separate major stages: the qualification phase and the final phase.

1. The Qualification Exam

The qualifications are based on a **single 3-hour written exam**, structured into four independent parts, corresponding to the key areas of the competition:

- **Mathematics**: 10 MCQs
- **Computer Programming**: 10 MCQs (Without computer)
- **Technical Drawing**: 10 MCQs
- **Engineering**: 10 MCQs

Marking Scheme and Official Grading System

The entire exam consists of 40 questions, evaluated according to a rigorous grading system out of a total of **40 points**:

- **+1.0 point** for each correct answer;
- **-0.5 point** for each incorrect answer (penalty for wrong choice);
- **0.0 point** in case of no answer (unanswered question).

2. The Final Phase

In the finals, the qualified candidates will face **four distinct and in-depth exams**, each marked out of **40 points**. The level of requirement and intellectual endurance are enhanced through specific formats and durations:

- **Mathematics**: A **3-hour** problem-solving exam;
- **Computer Programming**: A **3-hour** practical or algorithmic exam;
- **Technical Drawing**: A **2-hour** application exam;
- **Technological Text Comprehension**: A **2-hour** analysis exam.

By the very diversity of these subjects, each candidate will approach this competition with her own strengths and areas of vulnerability; none of them can claim to master all of these cutting-edge disciplines from the start. The key to success lies in methodical preparation, open-mindedness, and the learning effort made to explore or deepen a new field. This booklet has been specifically designed to guide you, step by step, in this wonderful journey of self-transcendence.

We extend our warmest wishes for success to all the candidates from the ten regions of Cameroon who will read through this booklet and who have the audacity to take on this great scientific challenge against the best high school girls in the country.

0.1 Sample Qualification Exam

Exam Conditions

40 MCQs. 1 pt for a correct answer, -0.5 pt for a wrong choice, and 0 pt for abstention. Duration: **3 hours**.

Mathematics Section

Question 1 : Let $f : \mathbb{R} \to \mathbb{R}$ be a function satisfying the following functional equation for all $x \in \mathbb{R}$:

$$f(x - f(x)) + 3f(x) = 2x^3 - 4x + 7$$

Determine the exact value of $f(x)$.

A) $x^5 + 3x - 2$
B) $-2x + 3$
C) $x^2 + 1$
D) $x^2 + x - 1$
E) $x^3 + 2x + 1$

Question 2 : Which of the following polynomials simultaneously satisfies: $P(1) = 2; P(2) = 3; P(3) = 4$ and $P(4) = 11$?

A) $x + 1$
B) $x^2 - 2x + 3$
C) $x^3 - 6x^2 + 12x - 5$
D) $x^4 - 6x^3 - 5x + 1$
E) $x^5 - 6x^4 + 12x^3 - 11x^2 + 12x - 5$

Question 3 : What is the coefficient of x^7 in the expansion of the following polynomial expression:

$$P(x) = (1 + x)^3(1 + x^2)^4(1 + x^4)^5$$

A) 45
B) 72
C) 83
D) 95
E) 120

Question 4 : What is the units digit of the integer 7^{4056} in its decimal notation?

A) 7
B) 9
C) 3
D) 1
E) 5

Question 5 : Determine the smallest solution strictly greater than 100 for the following system of congruences:

$$\begin{cases} x \equiv 2 \pmod 7 \\ x \equiv 3 \pmod 5 \end{cases}$$

A) 103

B) 107

C) 113

D) 128

E) 143

Question 6 : Let ABC be a triangle such that $\angle ABC = 45°$ and $\angle ACB = 30°$. Let D be the intersection point of the angle bisector of $\angle BAC$ with the side BC. The perpendicular to AC passing through D is drawn, intersecting AC at E. What is the measure of the angle $\angle CDE$?

A) 45°

B) 60°

C) 30°

D) 75°

E) 15°

Question 7 : Let Γ be a circle with diameter AB and center O. Consider two points P and Q outside the circle such that the lines (AP) and (BQ) intersect at a point R located on the circle Γ. If the power of P with respect to Γ is rigorously equal to the power of Q with respect to Γ, what is the nature of the triangle OQP?

A) Right triangle at O

B) Isosceles triangle at O

C) Equilateral triangle

D) Scalene triangle

E) It cannot be determined with accuracy

Question 8 : Students in a class are asked to choose 1, 2, or 3 foreign languages among German, Spanish, and Chinese. 8 students choose all 3, 15 choose German and Spanish, 13 choose Spanish and Chinese, 11 choose Chinese and German, 9 choose only German, 13 choose only Spanish, and 20 choose only Chinese. Knowing that everyone chose at least one language, how many students are in the classroom?

A) 89

B) 100

C) 60

D) 120

E) 65

Question 9 : A bag contains 10 tokens numbered from 1 to 10. 3 tokens are drawn simultaneously from the bag. How many different draws allow obtaining a sum of numbers that is a multiple of 3?

A) 30
B) 40
C) 44
D) 42
E) 120

Question 10 : Determine the exact number of pairs of natural integers (x, y) that satisfy the following diophantine equation:

$$x^2 - y^2 = 2024$$

A) 4
B) 8
C) 2
D) 0
E) 16

Computer Programming Section

Instructions to candidates:

- Carefully analyze the source codes provided below (the Python algorithm on the left and its C++ equivalent on the right).
- Determine with accuracy the numerical value or final display generated by the execution of these programs, based on your reading of the script.

Problem 1.

Python Version:

```
terme = 10
raison = 7
for i in range(1, 100):
    terme = terme + raison
print(terme)
```

C++ Version:

```
#include <iostream>
int main() {
    double terme = 10;
    double raison = 7;
    for(int i = 1; i < 100; i++) {
        terme = terme + raison;
    }
    std::cout << terme;
}
```

What does this program output?

A) 10×7^{100} **B)** 703 **C)** 717 **D)** 7×10^{99} **E)** 710

Problem 2.

Python Version:

```
for x in range(20):
    for y in range(20):
        if x + y == 15 and 2*x + 4*y == 40:
            print(f"{x};{y}")
```

C++ Version:

```
#include <iostream>
int main() {
    for(int x=0; x<20; x++) {
        for(int y=0; y<20; y++) {
            if(x+y == 15 && 2*x + 4*y == 40) {
                std::cout << x << ";" << y;
            }
        }
    }
}
```

What does this program output?

A) 5;10 **B)** 10;5 **C)** 7;8 **D)** 8;7 **E)** 0;15

Problem 3.

Python Version:

```
import math
x = 2
resultat = x**2 + math.sqrt(2 + x)
print(int(resultat))
```

C++ Version:

```
#include <iostream>
#include <cmath>
int main() {
    double x = 2;
    double res = pow(x, 2) + sqrt(2 + x);
    std::cout << (int)res;
}
```

What does this program output?

A) 4 **B)** 5 **C)** 6 **D)** 8 **E)** 2

Problem 4.

Python Version:

```
L = 19
l = 7
valeur = 2 * (L + l)
print(valeur)
```

C++ Version:

```
#include <iostream>
int main() {
    int L = 19, l = 7;
    int valeur = 2 * (L + l);
    std::cout << valeur;
}
```

What does this program output?

A) 26 **B)** 52 **C)** 133 **D)** 45 **E)** 38

Problem 5.

Python Version:

```
T = [12.5, 4.0, 19.5, 7.2, 15.0,
     22.1, 8.3, 14.6, 3.1, 11.8]
v = T[0]
for x in T:
    if x > v:
        v = x
print(v)
```

C++ Version:

```
#include <iostream>
int main() {
    double T[10] = {12.5, 4.0, 19.5, 7.2,
                    15.0, 22.1, 8.3, 14.6,
                    3.1, 11.8};
    double v = T[0];
    for(int i=0; i<10; i++) {
        if(T[i] > v) v = T[i];
    }
    std::cout << v;
}
```

What does this program output?

A) 12.5 **B)** 19.5 **C)** 22.1 **D)** 3.1 **E)** 15.0

Problem 6.

Python Version:

```
v = 6
c = 0
while v != 1:
    c += 1
    if v % 2 == 0:
        v = v // 2
    else:
        v = 3 * v + 1
print(c)
```

C++ Version:

```
#include <iostream>
int main() {
    int v = 6, c = 0;
    while(v != 1) {
        c++;
        if(v % 2 == 0) v = v / 2;
        else v = 3 * v + 1;
    }
    std::cout << c;
}
```

What does this program output?

A) 3 **B)** 5 **C)** 6 **D)** 8 **E)** 10

Problem 7.

Python Version:

```
A = [0, 2, 5, 3, 8]
M = [0] * 5
M[1] = A[1]
for i in range(2, 5):
    M[i] = A[i] + min(M[i-1], M[i-2])
print(M[4])
```

C++ Version:

```
#include <iostream>
#include <algorithm>
int main() {
    int A[5] = {0, 2, 5, 3, 8};
    int M[5] = {0};
    M[1] = A[1];
    for(int i = 2; i < 5; i++) {
        M[i] = A[i] + std::min(M[i-1], M[i-2]);
    }
    std::cout << M[4];
}
```

What does this program output?

A) 18 **B)** 10 **C)** 13 **D)** 11 **E)** 15

Problem 8.

Python Version:

```
K = [10, 5, 2, 1]
s = 28
r = 0
for x in K:
    r += s // x
    s = s % x
print(r)
```

C++ Version:

```
#include <iostream>
int main() {
    int K[4] = {10, 5, 2, 1};
    int s = 28, r = 0;
    for(int i = 0; i < 4; i++) {
        r += s / K[i];
        s = s % K[i];
    }
    std::cout << r;
}
```

What does this program output?

A) 4 **B)** 5 **C)** 6 **D)** 7 **E)** 8

Problem 9.

Python Version:

```
g = 0
d = 15
c = 0
while g <= d:
    c += 1
    m = (g + d) // 2
    if m == 11:
        break
    elif m < 11: g = m + 1
    else: d = m - 1
print(c)
```

C++ Version:

```
#include <iostream>
int main() {
    int g = 0, d = 15, c = 0;
    while(g <= d) {
        c++;
        int m = (g + d) / 2;
        if(m == 11) break;
        else if(m < 11) g = m + 1;
        else d = m - 1;
    }
    std::cout << c;
}
```

What does this program output?

A) 1 **B)** 2 **C)** 3 **D)** 4 **E)** 5

Problem 10.

Python Version:

```
V = [1, 3, 5, 7, 9]
n = len(V)
for i in range(n // 2):
    V[i], V[n - 1 - i] = V[n - 1 - i], V[i]
print(V[1])
```

C++ Version:

```
#include <iostream>
int main() {
    int V[5] = {1, 3, 5, 7, 9};
    int n = 5;
    for(int i = 0; i < n / 2; i++) {
        int t = V[i];
        V[i] = V[n - 1 - i];
        V[n - 1 - i] = t;
    }
    std::cout << V[1];
}
```

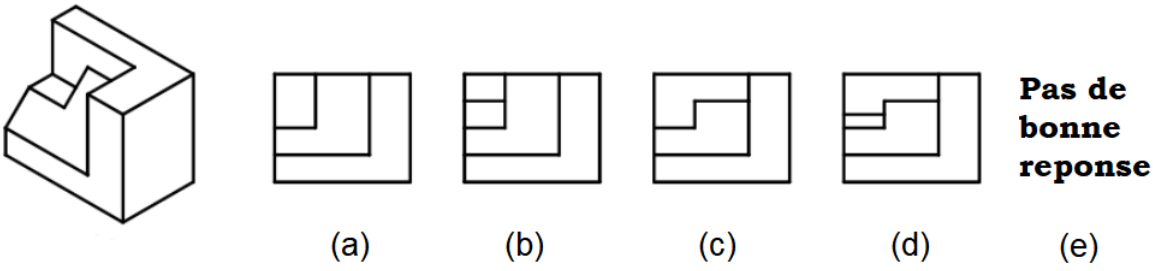
What does this program output?

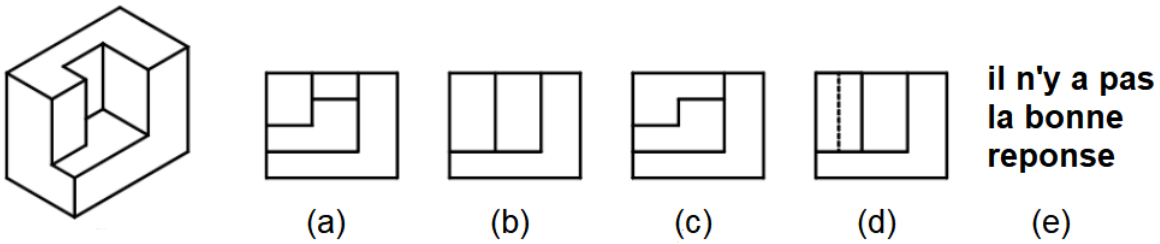
A) 1 **B)** 3 **C)** 5 **D)** 7 **E)** 9

Technical Drawing Section

For each given part, identify the correct view.
Attention! In the following, the representations of the views follow the Third-Angle Projection system (meaning the left view is to the left of the front view, the right view is to the right of the front view, the top view is above the front view, etc.)

1.



2. 
(a)
(b)
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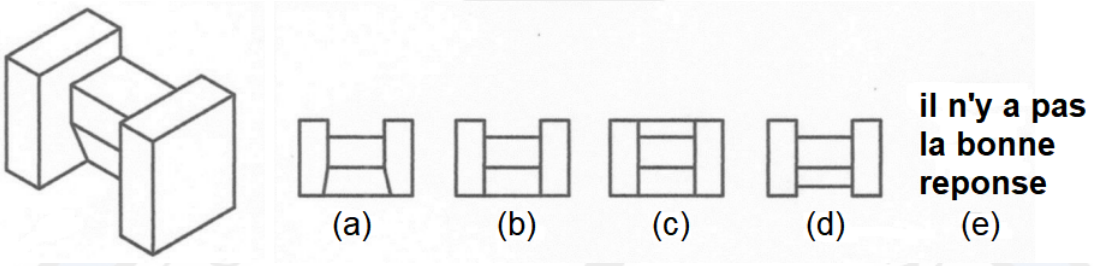
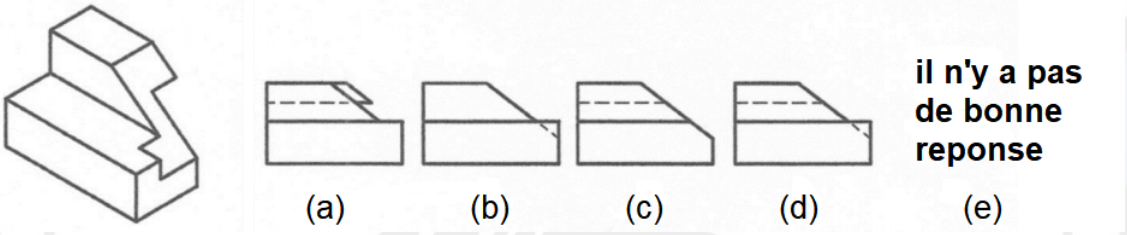
(d)
(e)
il n'y a pas la bonne reponse

3. 
(a)
(b)
(c)
(d)
(e)
il n'y a pas la bonne reponse

4. 
(a)
(b)
(c)
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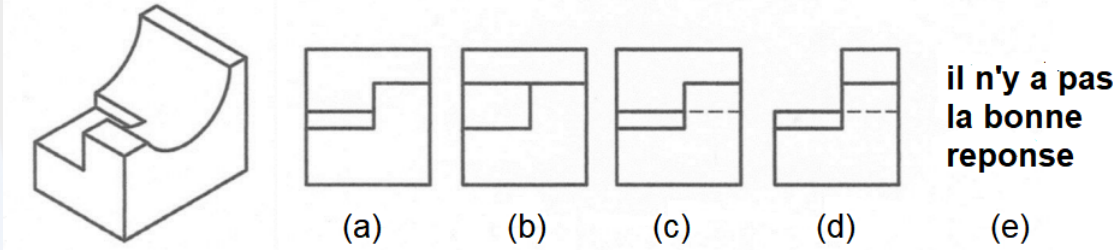
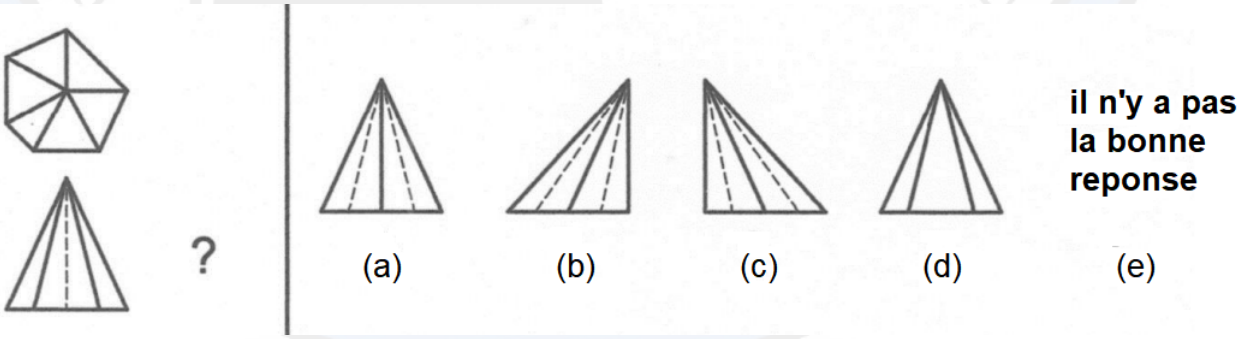
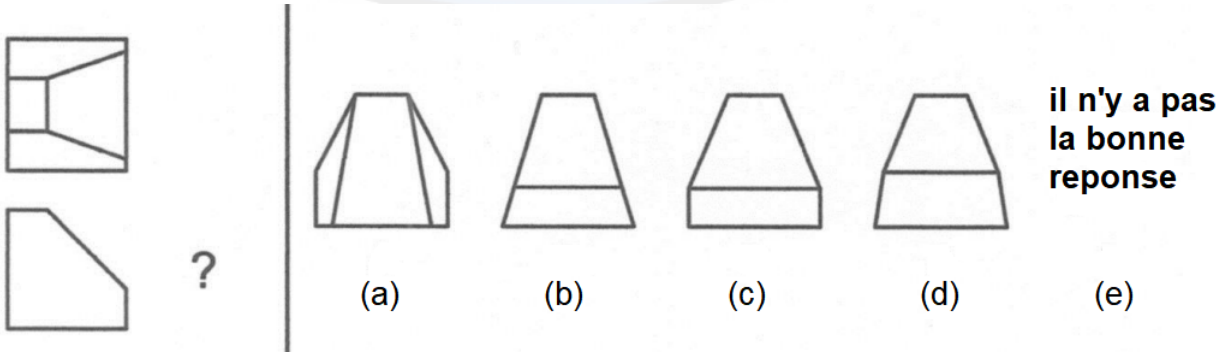
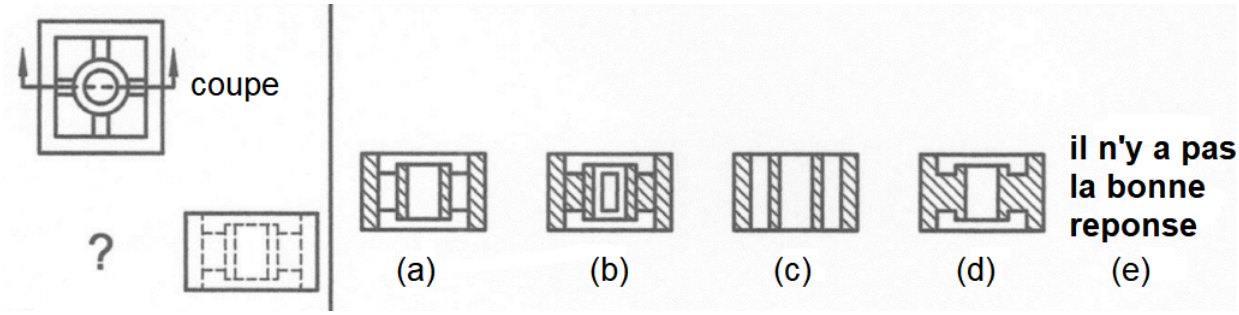
(e)
il n'y a pas de bonne reponse

5. 
(a)
(b)
(c)
(d)
(e)
il n'y a pas la bonne reponse

6. 
?
(a)
(b)
(c)
(d)
(e)
il n'y a pas la bonne reponse

7. 
?
(a)
(b)
(c)
(d)
(e)
il n'y a pas la bonne reponse

8.



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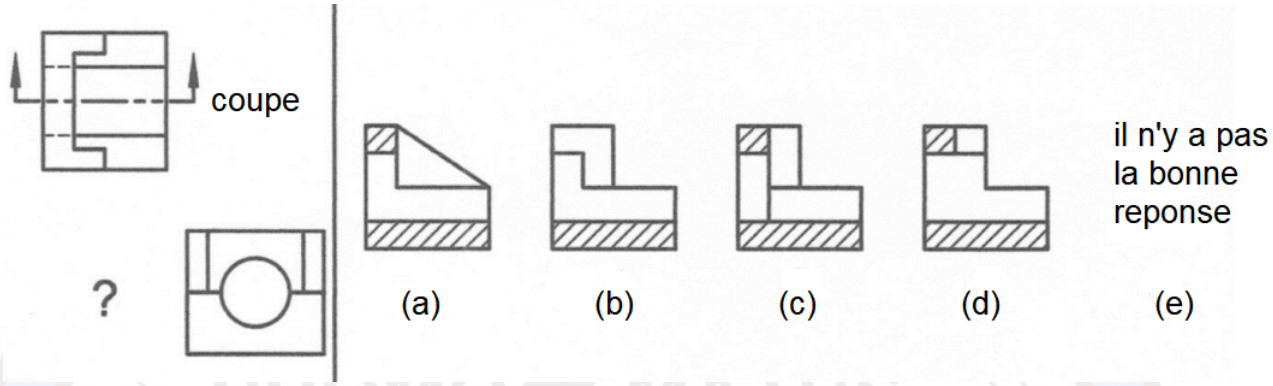
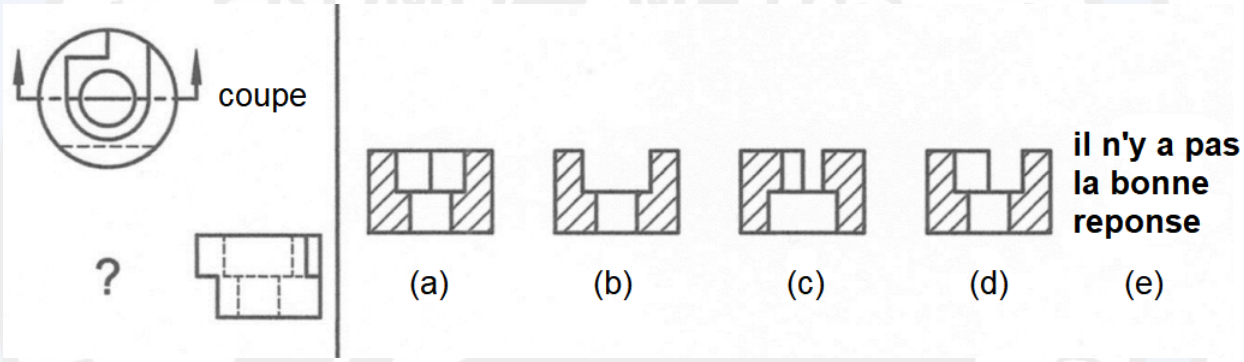


10.



Text Comprehension Section

TECHNICAL DATA SHEET: Milk Can Manufacturing in an Automated Factory

In a modern factory, the mass production of cylindrical milk cans uses very thin metal sheets called "tinplate" (steel coated with a layer of tin). These sheets have a thickness of **0.20 mm**.

The production line carries out three successive steps:

1. **Cutting and Shaping:** A machine first cuts metal rectangles to an exact length of **230 mm**. A second machine then rolls each rectangle to form the cylindrical tube of the can, and the two edges are electrically welded together.

2. **Assembling the Bottom:** A metal disk, which will serve as the bottom of the can, is attached to the cylindrical tube through a mechanical tight bending operation (called seaming/crimping). To ensure the structural strength of the can, the machine's pistons exert a constant compressed air pressure set at **6 bars**.

3. **Quality Control by Camera:** At the end of the line, each can passes in front of a high-speed camera connected to a computer. Software measures the outer diameter of the can: the expected ideal value is **73 mm**, with an accepted margin of error (tolerance) of only ± **0.05 mm**. Any diameter outside this margin is automatically rejected.

A. Direct Reading Questions (Find the information in the data sheet)

Q1. What is the thickness of the metal sheet (tinplate) used to manufacture the cans?

(a) 0.05 mm
(b) 0.20 mm
(c) 0.50 mm
(d) 73 mm
(e) 230 mm

Q2. At what compressed air pressure does the machine set its pistons to attach the bottom of the can?

(a) 2 bars
(b) 3 bars
(c) 5 bars
(d) 6 bars
(e) 73 bars

Q3. What is the margin of error (tolerance) accepted by the computer on the diameter of the can?

(a) ± 0.01 mm
(b) ± 0.05 mm
(c) ± 0.10 mm
(d) ± 0.20 mm
(e) ± 0.50 mm

Q4. What is the length of the metal rectangle cut at the very beginning of the line?

(a) 0.20 mm
(b) 6 mm
(c) 50 mm
(d) 73 mm
(e) 230 mm

Q5. What tool does the factory use at the very end of the line to measure and control the shape of the cans?

(a) A mechanical shear
(b) Pneumatic pistons
(c) A high-speed camera connected to a computer
(d) An electric welding machine
(e) Winding rollers

B. Reflection and Scientific Logic Questions

Q6. The camera measures a can and finds an outer diameter of **73.04 mm**. What decision will the computer make?

(a) It rejects the can because it exceeds 73.02 mm.
(b) It accepts the can because its size remains within the allowed margin of error (between 72.95 mm and 73.05 mm).
(c) It sends the can back to the beginning of the line to be re-rolled.
(d) It completely stops the whole factory so that the machining parameters can be reviewed.
(e) It accepts the can but slows down the speed of the conveyor belt.

Q7. The diameter of the can is 73 mm. Using the mathematical formula for the perimeter of a circle ($P = \pi \times$ Diameter), why do engineers cut the rectangle at a length of 230 mm rather than 220 mm?

(a) Because the raw perimeter is approximately 229.3 mm, and the 230 mm allows for a small extra piece to overlap and weld the edges together.

(b) Because the rectangle must be exactly three times the diameter of the can.

(c) Because the metal shrinks by half when rolled.

(d) To allow the camera to see the can better.

(e) To reduce the air pressure of the machine's pistons.

Q8. If the factory accidentally receives metal sheets that are twice as thick (0.40 mm instead of 0.20 mm), what physical problem will this pose to the machine that bends the bottom of the can?

(a) The machine will no longer need to exert force because the metal will be heavier.

(b) No problem, the force required to bend the metal always remains the same.

(c) The metal will be much more rigid and difficult to bend, requiring a much greater mechanical force.

(d) The machine will automatically transform into a control camera.

(e) The metal will melt on its own due to the weight of the sheet.

Q9. In chemistry and engineering, why is steel coated with a thin layer of tin (tinplate) used rather than pure iron or steel to manufacture a milk can?

(a) To make the can shine more in front of the control camera.

(b) To create a protective layer that prevents iron from rusting in contact with moisture and milk, thereby protecting the health of consumers.

(c) To reduce the diameter of the can and make it smaller.

(d) To make the metal transparent so that the milk can be seen through the can.

(e) To eliminate the need to use electricity in the factory.

Q10. Why is it essential that the machine fixing the bottom exerts a strong and well-adjusted air pressure (6 bars)?

(a) To help the computer calculate the dimensions of the can faster.

(b) To ensure that the metal is bent completely and uniformly, guaranteeing that the can is perfectly airtight (no milk leakage and no entry of microbes).

(c) To force the thickness of the can to change during assembly.

(d) To cool the metal after the electric welding step.

(e) To change the color of the can before its final packaging.

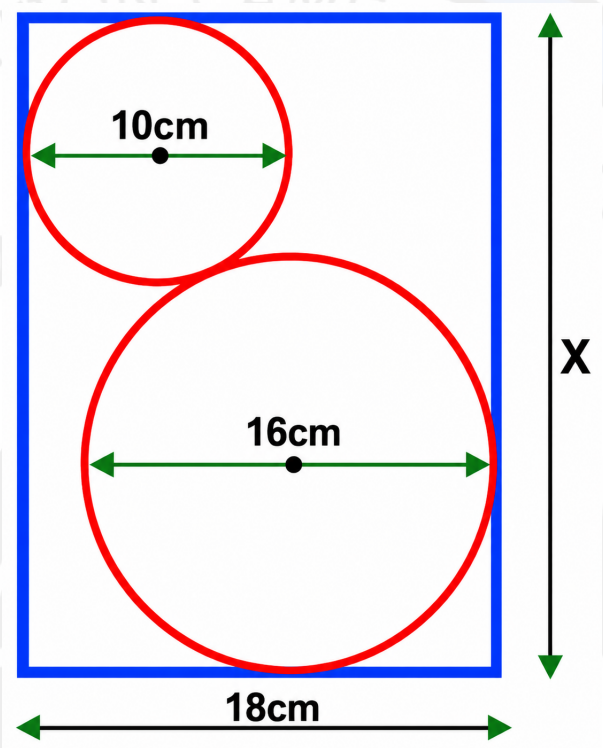
0.2 Sample Final Exams

Mathematics Exam: 3h (out of 40pts)

Main Instructions:

- Each candidate is invited to solve each of these 8 problems. The use of a calculator is not allowed.
- The first exercise of a theme is marked out of 3pts and the second out of 7pts.
- **It is very important to justify your answers.** Assertions without proof should be avoided.

Problem 1 : Geometry 1: Find the value of x:



Problem 2 : Geometry 2: Triangle T_1 has side lengths a_1, b_1, and c_1; its area is K_1.
Triangle T_2 has side lengths a_2, b_2, and c_2; its area is K_2.
Triangle T_3 has side lengths $a_1 + a_2, b_1 + b_2$, and $c_1 + c_2$; its area is K_3.
Prove that:

$$\sqrt{K_1} + \sqrt{K_2} \leq \sqrt{K_3}$$

Problem 3 : Algebra 1: Find the value of x such that: $81^{\sin^2 x} + 81^{\cos^2 x} = 30$

Problem 4 : Algebra 2: p, q, and r are the distinct roots of the polynomial: $x^3 - 22x^2 + 80x - 67$.
It is known that there exist real numbers A, B, and C such that:
$\frac{1}{x^3-22x^2+80x-67} = \frac{A}{s-p} + \frac{B}{s-q} + \frac{C}{s-r}$ for all $s \notin \{p, q, r\}$.
What is the value of the following number? $\frac{1}{A} + \frac{1}{B} + \frac{1}{C}$

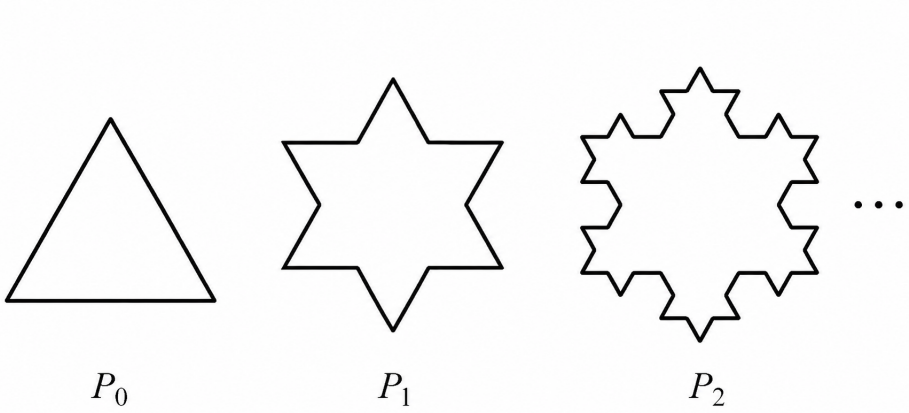
Problem 5 : Number Theory 1: Without using logarithms, calculate $\frac{1}{a} + \frac{1}{b}$ if a and b are two strictly positive real numbers satisfying: $7^a = 8^b = 56$

Problem 6 : Number Theory 2: A natural integer a is called a "lucky number" if the sum of its digits equals 7. All "lucky numbers" are arranged in increasing order to obtain a sequence $a_1, a_2, \ldots$.
If $a_n = 2\,005$, determine the exact value of a_{5n}.

Problem 7 : Combinatorics 1: A number N is written as $abcd$ in base 10, with $a \neq 0$. How many numbers N are there such that:

- $400 \leq N \leq 6000$
- N is a multiple of 5
- $3 \leq b < c \leq 6$

Problem 8 : Combinatorics 2: As shown in the diagram, consider a sequence of curves $P_0, P_1, P_2, \ldots$. It is known that the region bounded by P_0 has an area equal to 1 and that P_0 is an equilateral triangle. The curve P_{k+1} is obtained from P_k by performing the following operation: each side of P_k is divided into three equal segments (trisection), then an outward-oriented equilateral triangle is constructed on the central segment of each side, and finally, this central segment is removed ($k = 0, 1, 2, \ldots$). Let S_n be the area of the region bounded by the curve P_n. Find a formula for the general term of the sequence of numbers $\{S_n\}$; Determine $\lim_{n\to\infty} S_n$.



Computer Programming Exam: 3h (out of 40pts)

Problem 1: Solving a System of Equations [5 pts]
Solve the following system of equations in $\mathbb{R}^2$:

$$\begin{cases} xy + y^2 = 117 \\ x^2y - x = 140 \end{cases}$$

Problem 2: Sum of Triangular Numbers [5 pts]
Consider the sequence with general terms $T_0 = 0$, $T_1 = 1$, $T_2 = 1 + 2$, $T_3 = 1 + 2 + 3$, $\ldots$, $T_n = 1 + 2 + 3 + \cdots + n$.
Calculate the exact value of the following cumulative sum:

$$\sum_{k=1}^{100} T_k$$

Problem 3: Geometric Intersection of Functions [5 pts]
Find the precise Cartesian coordinates of the intersection point of the curves representing the functions f and g defined by:

$$f(x) = \sqrt{4 + x^5} \quad \text{and} \quad g(x) = 12 - 7x + x^3$$

Problem 4: Logico-Arithmetical Decryption of the Safe [5 pts]
To open this safe and win the challenge, the candidate must determine the unique 6-digit code $\overline{d_1d_2d_3d_4d_5d_6}$ simultaneously satisfying the following 5 constraints:

a) **Block of the first two digits:** The number formed by $\overline{d_1 d_2}$ is a prime number less than 50 whose units digit is odd and whose sum of digits is equal to 4.

b) **Third digit:** d_3 is the only strictly positive even digit that is equal to the sum of its proper divisors (a perfect number).

c) **Fourth digit:** d_4 is the remainder of the Euclidean division of the three-digit number $\overline{d_1 d_2 d_3}$ by 9.

d) **Block of the last two digits:** The fifth digit is strictly greater than the sixth ($d_5 > d_6$) and their product is equal to 12 ($d_5 \times d_6 = 12$).

e) **Global properties:** The complete 6-digit code is a multiple of 11, and the total sum of all its digits is an odd number.

Problem 5: Recursive Sequence of Triple General Order [5 pts]
Let f be a function defined on the set of natural integers $\mathbb{N}$ by the following relationships:

- $f(0) = 1$
- For every natural integer n:

$$\begin{aligned} f(3n) &= f(n) + 16 \\ f(3n+1) &= f(n) - 4 \\ f(3n+2) &= f(n) + 10 \end{aligned}$$

Calculate the exact value of the term $f(1\,000\,000)$.

Problem 6: Shortest Path Search (Dijkstra's Algorithm) [5 pts]
The table below models the road distances interconnecting 12 distinct localities named $A_1, A_2, \ldots, A_{12}$. All connections are bidirectional. Calculate the minimum total distance to connect locality A_1 to locality A_{12}.

Start	End	Distance (km)	Nature of the Connection
A_1	A_2	25 km	Main route
A_2	A_3	15 km	Main route
A_3	A_4	30 km	Main route
A_4	A_5	18 km	Main route
A_5	A_6	22 km	Main route
A_6	A_7	40 km	Main route
A_7	A_8	12 km	Main route
A_8	A_9	28 km	Main route
A_9	A_{10}	17 km	Main route
A_{10}	A_{11}	25 km	Main route
A_{11}	A_{12}	30 km	Main route
Shortcuts & Transverse Connections:			
A_1	A_4	60 km	Direct shortcut
A_3	A_7	55 km	Transverse route
A_4	A_9	80 km	Major secondary route
A_6	A_{10}	45 km	Connecting track
A_8	A_{12}	65 km	Direct highway

Problem 7: Asymptotic Analysis of a Prime Eulerian Product [5 pts]
Consider the sequence (u_n) defined for all integers $n \geq 2$ by:

$$u_n = \frac{n}{\pi(n) \cdot \ln(n)} \times \prod_{p \leq n} \left(1 + \frac{2}{p(p-1)}\right)$$

Where $\pi(n)$ represents the number of prime numbers less than or equal to n, and the symbol $\prod_{p \leq n}$ represents the product associated with all prime numbers p satisfying this bound. Calculate the stabilized approximate value of u_n at step $n = 100\,000$.

Problem 8: Modeling of a Dynamic Hydraulic Flow [5 pts]

A tank with a capacity of $V_{\text{total}} = 300$ liters is initially empty.

- A supply tap pours water at a constant flow rate of $D_{\text{tap}} = 1.8$ l/s.
- A puncture at its base generates a progressive leak dependent on the instantaneous water load, defined by the formula: $D_{\text{leak}} = 0.05 \times \sqrt{V_{\text{current}}}$.

Determine the total filling time of the tank at net flow rate, measured in seconds.

Technical Drawing Exam: 2h (out of 40pts)

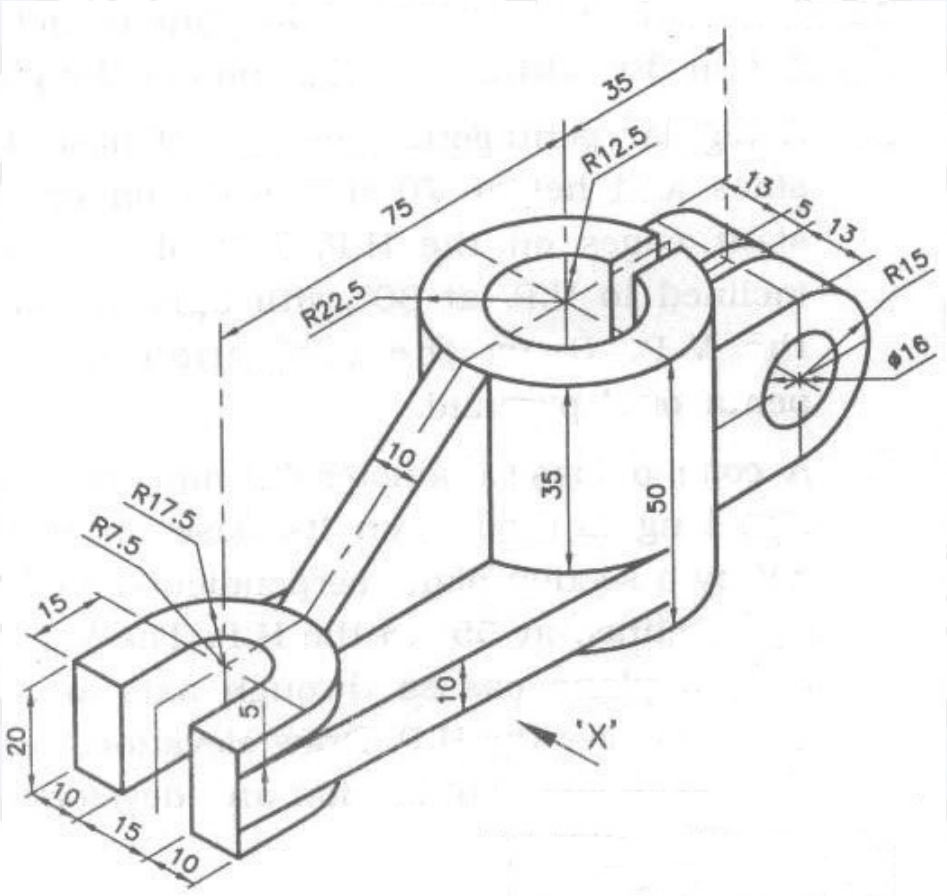
Here are some examples of parts for which front, top, right views, etc., sectioned or not, may be requested:

First Example:

Following the First-Angle Projection system (left view to the right of the front view, right view to the left of the front view, top view below the front view), represent this part as:

- front view,
- top view,
- left view.

N.B: All dimensions on the drawing are in *mm*.

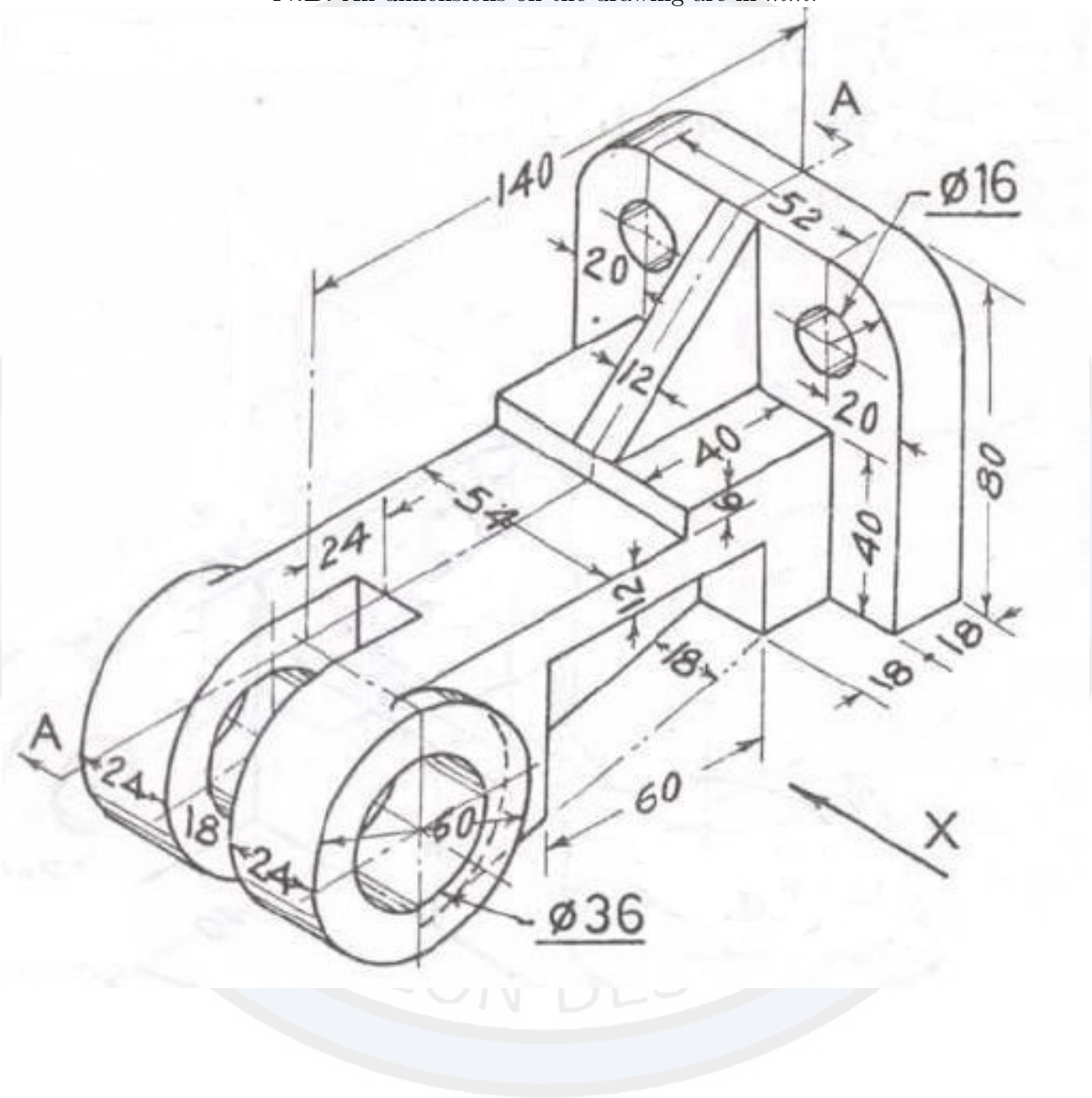


Second Example:

Represent this part as:

- front view (Section A-A),
- top view,
- left view.

N.B: All dimensions on the drawing are in mm.



Technological Text Comprehension Exam: 2h (out of 40pts)

PART I - FOUNDATIONAL TEXT: The Engineering of Smart Energy Grids and the Transition to the Renewable Mix in Cameroon

1. Introduction and Overview of the Interconnected Grid

The industrial and technological development of a nation intrinsically relies on the maturity of its energy engineering. In Cameroon, the electrical landscape is historically segmented into three distinct networks: the South Interconnected Grid (SIG), the North Interconnected Grid (NIG), and the East Interconnected Grid (EIG). This geographical fragmentation imposes heavy logistical and technical challenges on engineers in charge of load distribution (*dispatching*). In 2026, the national peak demand crossed the threshold of $1,400$ megawatts (MW), while the overall nominal installed capacity hovered around $1,650$ MW. However, the stable power actually available during the dry season frequently drops below $1,100$ MW, causing a critical imbalance between supply and demand.

The Cameroonian energy mix is characterized by an hyper-dependence on hydropower, which accounts for approximately 73% of national production, with the remainder provided by thermal power plants running on petroleum products (heavy fuel oil and natural gas). While hydropower offers the advantage of low-operating-cost, carbon-free energy, it suffers from high climate vulnerability due to seasonal variations in river flows. Modern engineering must therefore address a dual problem: diversifying production sources through the integration of intermittent renewable energies (solar and biomass) and intelligently interconnecting networks to optimize energy distribution across the entire national territory.

2. Hydroelectric Engineering and the Development of the Sanaga Basin

The Sanaga river basin forms the backbone of electricity production in Cameroon, concentrating more than 90% of the country's exploitable hydraulic potential. The Song Loulou (384 MW) and Édéa (276 MW) developments have long been the sole pillars of the SIG. Recently, the progressive commissioning of the Nachtigal hydroelectric complex (420 MW) structurally changed the game. From a technological perspective, Nachtigal utilizes vertical-axis *Francis*-type turbines, designed to optimize medium head heights (around 50 meters) with massive volume flow rates that can reach 980 m^3/s.

Electromagnetic induction, governed by Faraday's law, is exploited here on a large scale: the kinetic energy of the water rotates the generator's rotor, whose rotating magnetic field induces a three-phase alternating current in the coils of the fixed stator. The output voltage of the alternators, generally 15 kilovolts (kV), is immediately stepped up to 225 kV by step-up power transformers to minimize Joule heating losses ($P = R \cdot I^2$) during energy transmission over high-voltage lines to major consumption centers like Yaoundé and Douala.

However, hydropower from the Sanaga relies heavily on upstream storage and regulation dams, notably those at Mbakaou, Bamendjin, and Mapé. These reservoirs accumulate water during the rainy season to release it during the low-flow period (dry season), guaranteeing a regulated minimum flow rate of 600 m^3/s at the inlet of downstream production plants. Despite this regulation, prolonged drought cycles force engineers to design backup and diversification solutions.

3. Deployment of Solar Photovoltaics in the Far-North

The northern part of Cameroon (Adamawa, North, and Far-North regions), dependent on the NIG, features the highest solar irradiation indices in the country, reaching an average of 5.8 $kWh/m^2/day$.

It is within this context that photovoltaic engineering has taken off with the construction of the Guider and Maroua solar parks, totaling a capacity of 30 megawatt-peak (MWp).

The operating principle is based on the external photovoltaic effect, discovered by Edmond Becquerel. The modules consist of monocrystalline silicon cells doped to create a P-N junction. When a photon with energy greater than the bandgap of silicon (1.12 eV) strikes the cell, it knocks loose an electron, creating an electron-hole pair. The internal electric field of the junction pushes electrons toward the N zone and holes toward the P zone, generating a potential difference and a direct current (DC).

Integrating this energy into the NIG raises major system engineering challenges:

a) **Power Conversion:** The generated direct current must be transformed into a three-phase alternating current (AC) synchronous with the grid frequency (50 Hz). This task is assigned to high-power central inverters using high-frequency switching IGBT transistors.

b) **Intermittency:** Solar production stops abruptly at nightfall and fluctuates rapidly during the day due to cloud cover (ramp phenomenon). To stabilize the grid, engineers deployed a station-based Li-FePO4 (Lithium Iron Phosphate) battery storage system with a capacity of 20 megawatt-hours (MWh), managed by a dynamic regulation controller capable of injecting power in less than 10 milliseconds in the event of a frequency drop.

4. Biomass Valorization and Agro-Engineering in the East

The East region of Cameroon, covered by the EIG, possesses an exceptional forest and agricultural biomass resource. Thermal valorization engineering is developing there through cogeneration plants coupled with wood processing industries (sawmills). Biomass residues (sawdust, bark, offcuts) undergo complete combustion in an industrial boiler to produce water steam at high pressure (45 bars) and high temperature (400°C). This steam is injected into a back-pressure turbine coupled with an alternator to produce electricity. The low-pressure steam at the turbine outlet is not lost: it is redirected to the factory's wood dryers, thereby optimizing the overall thermodynamic efficiency of the installation according to the principle of cogeneration.

On a biochemical level, the valorization of municipal waste and industrial livestock manure is achieved through anaerobic digestion in sealed digesters. In the absence of oxygen, methanogenic bacteria degrade organic matter, producing biogas composed of approximately 60% methane (CH_4) and 40% carbon dioxide (CO_2). This biogas, after purification (removal of corrosive H_2S and moisture), powers an internal combustion thermal engine driving a local electrical generator.

5. Smart Grids and the Future of National Interconnection

To blend these different energy sources (stable hydropower, intermittent solar, local biomass, and backup thermal), the implementation of smart grid technologies has become essential. The modern architecture of a Smart Grid revolves around three technological layers:

- **The Physical and Power Layer:** High-voltage lines, smart transformers equipped with automatic on-load tap changers, and PMU (*Phasor Measurement Units*) sensors measuring voltage and current phase in real time at a frequency of 50 measurements per second.
- **The Communication Layer (IoT):** A mesh communication network using the MQTT protocol to transmit field sensor data to the national control center. This lightweight protocol, operating on a publish-subscribe model, guarantees smooth transmission even with reduced bandwidths.
- **The Software and Artificial Intelligence Layer:** A SCADA system coupled with a load prediction algorithm based on Transformer-type neural network architectures. This algorithm anticipates

electrical demand 24 hours in advance and automatically adjusts the startup of thermal plants and the storage of solar parks.

Thanks to these innovations, network engineering in Cameroon is preparing for the ultimate unification of the SIG, NIG, and EIG via the ultra-high-voltage transmission line (400 kV) between Nachtigal and the Adamawa region, paving the way for a resilient, modern, and 100% sovereign energy mix.

PART II: Evaluation Questionnaire (20 Questions)

Q1. *(Explicit)* In 2026, what is the peak national electricity demand in Cameroon according to the text?

(a) 1 100 MW
(b) 1 400 MW
(c) 1 650 MW
(d) 420 MW
(e) 600 MW

Q2. *(Explicit)* What precise type of vertical-axis hydraulic turbines is installed within the Nachtigal complex?

(a) Pelton
(b) Kaplan
(c) Francis
(d) Bulb
(e) Turgo

Q3. *(Explicit)* What is the nominal output voltage of the Nachtigal alternators before being stepped up by transformers?

(a) 15 kV
(b) 50 kV
(c) 225 kV
(d) 400 kV
(e) 11 kV

Q4. *(Explicit)* What average daily solar irradiation value characterizes the northern zone of Cameroon?

(a) $1,12$ eV
(b) 30 MWp
(c) $5,8$ kWh/m^2/day
(d) 20 MWh
(e) 50 Hz

Q5. *(Explicit)* What type of power transistors is used in central inverters to switch at high frequency?

(a) MOSFET
(b) JFET
(c) IGBT
(d) Triac
(e) Thyristor

Q6. *(Explicit)* What specific chemical technology was chosen for the 20 MWh stationary storage batteries deployed in the North?

(a) Lead-Acid (Pb)
(b) Conventional Lithium-Ion (LiCoO2)
(c) Nickel-Cadmium (NiCd)
(d) Lithium Iron Phosphate (Li-FePO4)
(e) Sodium-Sulfur (NaS)

Q7. *(Explicit)* In the agro-engineering of the East region, under what conditions of pressure and temperature does water steam leave the biomass boiler?

(a) 15 bars and 100°C
(b) 45 bars and 400°C
(c) 225 bars and 600°C
(d) 400 bars and 45°C
(e) 50 bars and 250°C

Q8. *(Explicit)* What is the approximate average biochemical composition of the raw biogas produced by anaerobic digestion in the text?

(a) 100% Methane (CH_4)
(b) 50% Oxygen (O_2) and 50% Nitrogen (N_2)
(c) 60% Methane (CH_4) and 40% Carbon dioxide (CO_2)
(d) 90% Natural gas and 10% Hydrogen sulfide (H_2S)
(e) 40% Methane (CH_4) and 60% Carbon monoxide (CO)

Q9. *(Explicit)* Which publish-subscribe communication protocol governs the IoT communication layer of Smart Grids?

(a) HTTP
(b) SCADA
(c) PMU
(d) MQTT
(e) FTP

Q10. *(Explicit)* What neural network architecture based on attention mechanisms is integrated into the predictive management SCADA software?

(a) Convolutional Networks (CNN)
(b) Recurrent Networks (RNN)
(c) Transformers
(d) Multilayer Perceptrons (MLP)
(e) Hopfield Networks

Q11. *(Deductive)* Based on the status report presented in the text, which statement best describes the energy situation during the dry season in Cameroon?

(a) Available power largely covers peak demand thanks to thermal power plants.
(b) The grid suffers a critical deficit of at least 300 MW during peak hours.
(c) Overall nominal installed capacity decreases by one third.

(d) The energy mix automatically shifts to 100% thermal production.

(e) The South Interconnected Grid stops functioning to the benefit of the EIG.

Q12. *(Deductive)* Why do engineers step up the voltage to 225 kV to transmit energy from the Nachtigal power plant?

(a) To increase the travel speed of electrons in copper lines.

(b) To comply with Faraday's law on line electromotive force.

(c) To reduce current intensity at equal power and thus reduce thermal transmission losses along the line.

(d) To directly transform alternating current into direct current.

(e) To bypass the climate dependence of upstream storage dams.

Q13. *(Deductive)* If the volume flow rate at the Nachtigal power plant reaches its maximum value mentioned in the text, what volume of water passes through the turbines in exactly one minute?

(a) 980 m^3

(b) 420 m^3

(c) 58 800 m^3

(d) 600 m^3

(e) 25 200 m^3

Q14. *(Deductive)* What is the fundamental geostrategic and technical role of the Mbakaou, Bamendjin, and Mapé dams with respect to the Nachtigal complex?

(a) They house the 225 kV step-up transformers.

(b) They convert direct current from northern solar parks.

(c) They act as water buffer stocks to artificially maintain a sufficient flow rate during the dry season.

(d) They directly capture solar irradiation from the north.

(e) They filter sawdust and bark coming from the East region.

Q15. *(Deductive)* A photon carrying a quantum energy of 0.95 eV strikes a silicon cell at the Maroua solar park. What happens physically?

(a) It creates a very strong electron-hole pair due to the doping of the N junction.

(b) The electron is knocked loose but remains trapped in the P zone.

(c) Nothing happens because the photon's energy is less than the material's bandgap.

(d) The photon instantly increases the NIG grid frequency beyond 50 Hz.

(e) Direct current (DC) instantly switches to alternating current (AC).

Q16. *(Deductive)* Analyzing the operation of the central inverters described, what is their primary mathematical and physical role?

(a) Changing the bandgap of monocrystalline silicon.

(b) Raising peak continuous power from 30 MWp to 50 MWp.

(c) Turning an initially continuous physical quantity into an alternating one while synchronizing its frequency and phase with the host grid.

(d) Storing excess energy to release it at night in less than 10 milliseconds.

(e) Purifying biogas by removing corrosive sulfur compounds.

Q17. *(Deductive)* In the case of cogeneration plants in the East, why is the overall thermodynamic efficiency qualified as "optimized" compared to a conventional thermal plant?

(a) Because it uses Francis turbines with a high head height.

(b) Because the same primary thermal energy source simultaneously produces two useful forms of energy (electrical and thermal/calorific).

(c) Because it transforms methane into pure carbon dioxide before combustion.

(d) Because it operates exclusively without any presence of oxygen.

(e) Because it directly steps up line voltage to 400 kV.

Q18. *(Deductive)* Why is biogas purification (removal of moisture and H_2S) a mandatory engineering step before its injection into the thermal engine?

(a) To prevent the multiplication of anaerobic methanogenic bacteria.

(b) To guarantee that the induced current strictly respects Ohm's law.

(c) To preserve the mechanical and chemical integrity of the engine by avoiding early corrosion phenomena.

(d) To lower water steam pressure from 45 bars to 1 bar.

(e) To allow PMU sensors to measure gas phase at 50 Hz.

Q19. *(Deductive)* What is the concrete purpose of deploying PMU (*Phasor Measurement Units*) sensors at the physical layer of Smart Grids?

(a) To regulate the temperature of wood dryers in the East region.

(b) To ensure complete combustion of wood sawdust in boilers.

(c) To obtain a dynamic and ultra-fast mapping of the network's electrical stability state in order to prevent widespread blackouts.

(d) To replace 225 kV high-voltage lines with mesh IoT cables.

(e) To destroy carbon dioxide molecules produced by methanization.

Q20. *(Deductive)* What major technical objective justifies the creation of the future 400 kV ultra-high-voltage transmission line between Nachtigal and Adamawa?

(a) Doubling the overall grid frequency to reach 100 Hz.

(b) Allowing massive energy transfer between the South (SIG) and the North (NIG) to pool resources and eliminate fragmentation.

(c) Completely eliminating the use of Li-FePO4 battery storage technology.

(d) Forcing the Sanaga basin to flow toward the Far-North region.

(e) Totally eliminating the influence of Joule heating on the Douala distribution network.

SOLUTIONS AND ANSWER KEY

Correction of the Qualification Exam

Mathematics Section

Question 1 — Correct Answer: D $(x^2 + x - 1)$
Analysis of the right-hand side allows us to deduce that the degree of f cannot be 1, nor greater than 2. This reduces the cases to test: We only test C) and D).

Question 2 — Correct Answer: C $(x^3 - 6x^2 + 12x - 5)$
One of the best strategies is to test each option. Since the first 3 conditions work for $x + 1$, another

method consists in setting: $P(x) = a(x-1)(x-2)(x-3) + x + 1$. We plug in $P(4) = 11$ to determine the value of $a = 1$.

Question 3 — Correct Answer: C (83)
You can carefully expand and reduce to obtain:
$x^{31} + 3x^{30} + 7x^{29} + 13x^{28} + 23x^{27} + 37x^{26} + 57x^{25} + 83x^{24} + 113x^{23} + 147x^{22} + 183x^{21} + 221x^{20} + 255x^{19} + 285x^{18} + 305x^{17} + 315x^{16} + 315x^{15} + 305x^{14} + 285x^{13} + 255x^{12} + 221x^{11} + 183x^{10} + 147x^9 + 113x^8 + 83x^7 + 57x^6 + 37x^5 + 23x^4 + 13x^3 + 7x^2 + 3x + 1$
And here, we clearly see that **83** is in front of x^7.

Another way consists in analyzing:
The expression is $P(x) = (1+x)^3(1+x^2)^4(1+x^4)^5$. By Newton's binomial formula, the general term of each factor is respectively: $\binom{3}{a}x^a$, $\binom{4}{b}x^{2b}$, and $\binom{5}{c}x^{4c}$. We look for all triplets of integers (a, b, c) such that $0 \leq a \leq 3$, $0 \leq b \leq 4$, $0 \leq c \leq 5$ satisfying the exponent equation:

$$a + 2b + 4c = 7$$

Let's list the possible choices for c (the coefficient before the highest power):

- If $c = 1$: $a + 2b = 3$.
  - If $b = 1$, then $a = 1$. Contribution: $\binom{3}{1}\binom{4}{1}\binom{5}{1} = 3 \times 4 \times 5 = 60$.
  - If $b = 0$, then $a = 3$. Contribution: $\binom{3}{3}\binom{4}{0}\binom{5}{1} = 1 \times 1 \times 5 = 5$.
- If $c = 0$: $a + 2b = 7$.
  - If $b = 3$, then $a = 1$. Contribution: $\binom{3}{1}\binom{4}{3}\binom{5}{0} = 3 \times 4 \times 1 = 12$.
  - If $b = 2$, then $a = 3$. Contribution: $\binom{3}{3}\binom{4}{2}\binom{5}{0} = 1 \times 6 \times 1 = 6$.

The total sum of contributions is: $60 + 5 + 12 + 6 = 83$.

Question 4 — Correct Answer: D (1)
Analysis: The units digit of a number in base 10 corresponds to its remainder modulo 10. Let's study the successive powers of 7 (mod 10):

$$7^1 \equiv 7, \quad 7^2 \equiv 9, \quad 7^3 \equiv 3, \quad 7^4 \equiv 1 \pmod{10}$$

The cycle of remainders is therefore of length 4 $(7, 9, 3, 1)$. Let's determine the remainder of the Euclidean division of the exponent 4056 by 4: $4056 = 4 \times 1014$, so $4056 \equiv 0 \pmod 4$. Therefore, $7^{4056} \equiv 7^4 \equiv 1 \pmod{10}$. The units digit is 1.

Question 5 — Correct Answer: D (128)
Analysis: We have the system:

$$\begin{cases} x \equiv 2 \pmod 7 \\ x \equiv 3 \pmod 5 \end{cases}$$

From the second congruence, x can be written in the form $x = 5k + 3$. Let's substitute this expression into the first congruence:

$$5k + 3 \equiv 2 \pmod 7 \iff 5k \equiv -1 \equiv 6 \pmod 7$$

Multiply by 3 (the inverse of 5 modulo 7 because $3 \times 5 = 15 \equiv 1 \pmod 7$):

$$k \equiv 18 \equiv 4 \pmod 7$$

So $k = 7m + 4$. Substituting k, we get the general solution:

$$x = 5(7m + 4) + 3 = 35m + 23$$

We look for the smallest solution strictly greater than 100:

- For $m = 1$, $x = 58 \leq 100$.
- For $m = 2$, $x = 93 \leq 100$.
- For $m = 3$, $x = 35(3) + 23 = 105 + 23 = 128$.

The answer is 128.

Question 6 — Correct Answer: B ($60°$)
Consider the right triangle DEC. By construction, line (DE) is perpendicular to line (AC), implying that triangle DEC is right-angled at E. In any right triangle, the sum of the two acute angles is equal to $90°$. Here, angle $\angle ECD$ coincides with angle $\angle ACB$ of the initial triangle, whose measure is given: $\angle ACB = 30°$. Therefore, in the right triangle DEC at E:

$$\angle CDE = 90° - \angle ECD = 90° - 30° = 60°$$

Note: The data concerning angle $\angle ABC = 45°$ and the bisector AD are not used for the direct calculation of this angle; it is a classic Olympiad trap to test the student's geometric focus.

Question 7 — Correct Answer: B (Isosceles triangle at O)
The power of any point M with respect to a circle Γ with center O and radius R is defined by the metric formula $\mathcal{P}(M) = OM^2 - R^2$. The problem states that the power of point P is equal to that of point Q, which translates to:

$$OP^2 - R^2 = OQ^2 - R^2 \iff OP = OQ$$

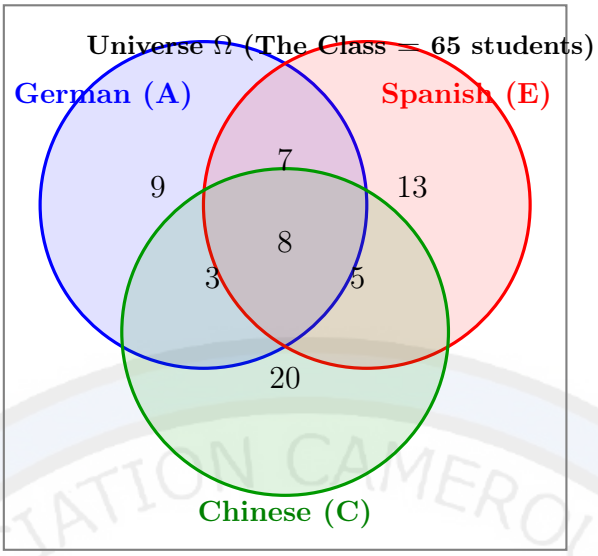
So the triangle is isosceles at O. By moving points Q and P further apart or closer together, angle $\angle POQ$ varies. Its value cannot be fixed at $60°$, for instance. This rules out the possibility of it being equilateral.

Question 8 — Correct Answer: E (65)
Analysis: We can reason in terms of the cardinalities of well-defined sets: Let A, E, and C be the sets of students studying German, Spanish, and Chinese respectively. From the text (rectifying the repetition with the Spanish and Chinese intersection), we isolate the size of each exclusive zone:

- All 3 languages simultaneously: 8 students.
- German and Spanish only: $15 - 8 = 7$ students.
- Spanish and Chinese only: $13 - 8 = 5$ students.
- Chinese and German only: $11 - 8 = 3$ students.
- German only: 9 students.
- Spanish only: 13 students.
- Chinese only: 20 students.

The total number of students in the room is the sum of these disjoint subsets:

$$\text{Total} = 9 + 13 + 20 + 7 + 5 + 3 + 8 = 65 \text{ students.}$$



Question 9 — Correct Answer: D (42)
Let's classify the integers from 1 to 10 according to their remainder in the Euclidean division by 3 (congruence classes modulo 3):

- Class R_0 (remainders equal to 0): $\{3, 6, 9\}$ — Contains 3 elements.
- Class R_1 (remainders equal to 1): $\{1, 4, 7, 10\}$ — Contains 4 elements.
- Class R_2 (remainders equal to 2): $\{2, 5, 8\}$ — Contains 3 elements.

For the sum of three numbers to be a multiple of 3, there are two possible configurations for their remainders:

1) **All three numbers belong to the same class:** In R_0: $\binom{3}{3} = 1$ way; In R_1: $\binom{4}{3} = 4$ ways; In R_2: $\binom{3}{3} = 1$ way. Subtotal $= 1 + 4 + 1 = 6$ ways.
2) **Exactly one number is chosen from each class (R_0, R_1, R_2):** Number of ways: $\binom{3}{1} \times \binom{4}{1} \times \binom{3}{1} = 3 \times 4 \times 3 = 36$ ways.

The general total is therefore $6 + 36 = 42$ valid draws.

Question 10 — Correct Answer: A (4)
The Diophantine equation is written in factored form: $(x - y)(x + y) = 2024$. Let $u = x - y$ and $v = x + y$. Since $x, y \in \mathbb{N}$, we have $u \leq v$, and u, v must have the same parity because their sum $u + v = 2x$ is even. Since their product $uv = 2024$ is even, u and v are necessarily both even. Let's decompose 2024 into prime factors: $2024 = 2^3 \times 11 \times 23 = 8 \times 11 \times 23$. Since u and v are even, we can set $u = 2a$ and $v = 2b$, which gives:

$$(2a)(2b) = 2024 \iff a \times b = 506$$

The number of pairs (x, y) of natural integers sought is equal to the number of ways to factor 506 in the form $a \times b$ with $a \leq b$. Prime factorization of 506: $506 = 2 \times 11 \times 23$. The total number of divisors of 506 is $(1 + 1)(1 + 1)(1 + 1) = 8$. The number of pairs of divisors (a, b) such that $a \leq b$ is therefore $8/2 = 4$. Each of these pairs yields a unique pair of positive solutions (x, y). There are therefore exactly 4 pairs of solutions.

Computer Programming Section

Problem 1 : B	**Problem 2 : B**	**Problem 3 : C**	**Problem 4 : B**	**Problem 5 : C**
Problem 6 : D	**Problem 7 : D**	**Problem 8 : B**	**Problem 9 : C**	**Problem 10 : D**

Explanations:

P1 (B) : The loop performs 99 iterations (from 1 to 99). With an initial term of 10 to which the common difference (7) is added at each iteration, the final calculation is $10 + 7 \times 99 = 703$.

P2 (B) : Scanning the single solution of the system: $x + y = 15$ and $2x + 4y = 40$. The valid pair displayed is $10, 5$.

P3 (C) : Evaluation: $2^2 + \sqrt{2+2} = 4 + 2 = 6$.

P4 (B) : Perimeter calculation: $2 \times (19 + 7) = 52$.

P5 (C) : Classic maximum search. The largest value in the list is 22.1.

P6 (D) : Collatz sequence for $n = 6$: $6 \to 3 \to 10 \to 5 \ldots$ The counter indicates 8.

P7 (D) : Calculation of the minimum path cost (dynamic programming): 'M[0] = 0', 'M[1] = 2', 'M[2] = 5 + min(2, 0) = 5', 'M[3] = 3 + min(5, 2) = 5', 'M[4] = 8 + min(5, 5) = 13'.

P8 (B) : Greedy coin change for the sum 28: two 10-coins, one 5-coin, one 2-coin, and one 1-coin. Total: 5 coins.

P9 (C) : Binary search steps on the interval $[0, 15]$: Step 1: 'm = (0+15)//2 = 7' ($7 < 11 \implies g = 8$); Step 2: 'm = (8+15)//2 = 11'. Equality found. The counter is 2.

P10 (D) : Symmetric inversion of the array. The list becomes '[9, 7, 5, 3, 1]'. The element at index 1 is the value 7.

Technical Drawing Section

The following table presents the correct options (Note that the system of representation is Third-Angle Projection).

1	2	3	4	5	6	7	8	9	10
(c)	(b)	(b)	(d)	(c)	(a)	(c)	(d)	(e)	(d)/

Technological Text Comprehension Section

Q1 : B	**Q2 : C**	**Q3 : A**	**Q4 : C**	**Q5 : C**
Q6 : B	**Q7 : A**	**Q8 : C**	**Q9 : B**	**Q10 : B**

Logical Explanations for the Reflection Questions:

Q6 (B) : The target is 73 mm with a tolerance of ±0.05 mm. The accepted range is therefore from 72.95 mm to 73.05 mm. Since 73.04 is less than 73.05, the can complies and is validated.

Q7 (A) : The circumference of the can is $\pi \times 73 \approx 229.33$ mm. By cutting at 230 mm, a slight excess of a third of a millimeter is kept, which is essential to overlap the two edges of the rectangle and perform the weld line.

Q8 (C) : The thicker a metal sheet, the greater its moment of inertia (its geometric resistance to deformation). Doubling the thickness requires significantly higher bending energy, which can strain or jam the machines if the pressure is not readjusted.

Q9 (B) : Milk contains a high proportion of water. In contact with water and oxygen, raw steel oxidizes and creates rust (text: iron oxide), unfit for consumption. Tin is a stable metal that acts as a food safety shield.

Q10 (B) : Seaming/crimping is a deformation by forced bending. If the pressure is insufficient (less than 6 bars), the fold will be loose, letting air, liquid, or external microorganisms pass through, which would spoil the milk.

Correction of the Sample Final Exams

Mathematics Exam

Solution 1 : Geometry 1 :

Let A and B be the centers of the large and small circles, respectively. We have $A(10, 8)$ and $B(5, x-5)$. Therefore, the Euclidean distance between A and B yields: $\sqrt{25+(x-13)^2} = 13$, from which we obtain $(x-13)^2 = 144$ and thus, $x = 25$.

Solution 2 : Geometry 2 :

Let s_1, s_2, s_3 be the semi-perimeters of triangles T_1, T_2, and T_3, respectively. By hypothesis on the side lengths, we immediately have $s_3 = s_1 + s_2$. Let's introduce the variables associated with Heron's formula:

$$x_1 = s_1 - a_1, \quad y_1 = s_1 - b_1, \quad z_1 = s_1 - c_1$$
$$x_2 = s_2 - a_2, \quad y_2 = s_2 - b_2, \quad z_2 = s_2 - c_2$$

Thus, for triangle T_3, we have $x_3 = x_1 + x_2$, $y_3 = y_1 + y_2$, and $z_3 = z_1 + z_2$. According to Heron's formula, the area of a triangle is expressed as $K = \sqrt{s(s-a)(s-b)(s-c)}$. The required inequality becomes:

$$(s_1x_1y_1z_1)^{1/4} + (s_2x_2y_2z_2)^{1/4} \leq [(s_1+s_2)(x_1+x_2)(y_1+y_2)(z_1+z_2)]^{1/4}$$

This relationship follows directly from Hölder's inequality (or Minkowski's inequality for products) applied to two quadruplets of strictly positive real numbers:

$$\prod_{i=1}^{4} u_i^{1/4} + \prod_{i=1}^{4} v_i^{1/4} \leq \prod_{i=1}^{4} (u_i + v_i)^{1/4}$$

By setting $(u_1, u_2, u_3, u_4) = (s_1, x_1, y_1, z_1)$ and $(v_1, v_2, v_3, v_4) = (s_2, x_2, y_2, z_2)$, the inequality is proven. Equality holds if and only if T_1 and T_2 are similar.

Solution 3 : Algebra 1 :

Since $\cos^2 x = 1 - \sin^2 x$, the equation $81^{\sin^2 x} + 81^{\cos^2 x} = 30$ can be rewritten as:

$$81^{\sin^2 x} + \frac{81}{81^{\sin^2 x}} = 30$$

Let's use the change of variable $y = 81^{\sin^2 x}$ with $y > 0$. We obtain the quadratic equation: $y^2 - 30y + 81 = 0$. The roots of this equation are $y = 3$ and $y = 27$ (since $3 \times 27 = 81$ and $3 + 27 = 30$).

- **Case 1:** $81^{\sin^2 x} = 3 \iff 3^{4\sin^2 x} = 3^1 \iff 4\sin^2 x = 1 \iff \sin^2 x = \frac{1}{4}$, i.e., $\sin x = \pm\frac{1}{2}$.
  Hence $x = \pm\frac{\pi}{6} + k\pi$, $k \in \mathbb{Z}$.
- **Case 2:** $81^{\sin^2 x} = 27 \iff 3^{4\sin^2 x} = 3^3 \iff 4\sin^2 x = 3 \iff \sin^2 x = \frac{3}{4}$, i.e., $\sin x = \pm\frac{\sqrt{3}}{2}$.
  Hence $x = \pm\frac{\pi}{3} + k\pi$, $k \in \mathbb{Z}$.

The solution set is the union of these two families of real numbers.

Solution 4 : Algebra 2 :

Let $P(x) = x^3 - 22x^2 + 80x - 67$. By partial fraction decomposition of a rational function

with simple poles, the coefficients A, B, and C are obtained by the formula $A = \frac{1}{P'(p)}$, $B = \frac{1}{P'(q)}$, and $C = \frac{1}{P'(r)}$. The required expression is therefore:

$$\frac{1}{A} + \frac{1}{B} + \frac{1}{C} = P'(p) + P'(q) + P'(r)$$

The derivative of P is $P'(x) = 3x^2 - 44x + 80$. We deduce:

$$\frac{1}{A} + \frac{1}{B} + \frac{1}{C} = 3(p^2 + q^2 + r^2) - 44(p + q + r) + 240$$

According to Vieta's formulas applied to $P(x)$: $p + q + r = 22$, $pq + qr + rp = 80$, and $p^2+q^2+r^2 = (p+q+r)^2-2(pq+qr+rp) = 22^2-2(80) = 484-160 = 324$. Substituting these values, we get:

$$\frac{1}{A} + \frac{1}{B} + \frac{1}{C} = 3(324) - 44(22) + 240 = 972 - 968 + 240 = \mathbf{244}$$

Solution 5 : Number Theory 1 :

By the definition of exponents, the equations $7^a = 56$ and $8^b = 56$ imply respectively: $7 = 56^{1/a}$ and $8 = 56^{1/b}$. Multiplying these two equations member by member, we get:

$$7 \times 8 = 56^{1/a} \times 56^{1/b} \iff 56^1 = 56^{\frac{1}{a}+\frac{1}{b}}$$

By identifying the exponents, it follows immediately: $\frac{1}{a} + \frac{1}{b} = \mathbf{1}$.

Solution 6 : Number Theory 2 :

Let's first determine the rank n of the lucky number 2 005 by counting the lucky numbers less than or equal to it:

a) **1 to 3-digit numbers (≤ 999):** equivalent to $x_1 + x_2 + x_3 = 7 \implies \binom{7+3-1}{3-1} = \binom{9}{2} = 36$.

b) **4-digit numbers starting with 1 ($1abc$):** satisfy $a + b + c = 6 \implies \binom{6+3-1}{3-1} = \binom{8}{2} = 28$.

c) **4-digit numbers starting with 2 ($2abc$) less than 2005:** Only 2 005 works (1 possibility).

The rank of 2 005 is therefore $n = 36 + 28 + 1 = 65$. We want to evaluate $a_{5n} = a_{325}$. Let's calculate the total number of 4 and 5-digit solutions:

- Total 4-digit numbers: $\binom{6+4-1}{4-1} = \binom{9}{3} = 84$. Cumulative total: $36 + 84 = 120$ numbers $\leq 9\,999$.
- Total 5-digit numbers: $\binom{6+5-1}{5-1} = \binom{10}{4} = 210$. Cumulative total: $120 + 210 = 330$ numbers $\leq 99\,999$.

The 330^{th} number is the largest lucky number with 5 digits (70 000). Listing in descending order: $a_{330} = 70\,000$, $a_{329} = 61\,000$, $a_{328} = 60\,100$, $a_{327} = 60\,010$, $a_{326} = 60\,001$, $a_{325} = 52\,000$. The exact value of a_{5n} is therefore **52 000**.

Solution 7 : Combinatorics 1 :

Let $N = abcd$ in base 10. Let's analyze the constraints of the problem:

- Since $a \neq 0$, N must have 4 digits. Thus, the condition becomes $1\,000 \leq N \leq 6\,000$.

- N is a multiple of 5 $\implies$ $d \in \{0, 5\}$ (2 choices).
- For the condition $3 \leq b < c \leq 6$, let's count the possible pairs (b, c): $(3, 4), (3, 5), (3, 6), (4, 5), (4, 6), (5, 6)$, making a total of 6 valid choices of pairs (b, c).

Let's now study the possible values for the first digit a:

- If $a \in \{1, 2, 3, 4, 5\}$ (5 choices): $5 \times 6 \times 2 = 60$ numbers.
- If $a = 6$: The constraint $N \leq 6\,000$ requires analyzing the single number 6 000. But for 6 000, we have $b = 0$ and $c = 0$, which contradicts the inequality $3 \leq b < c$. No solution emerges for $a = 6$.

There are therefore exactly **60** numbers meeting the criteria.

Solution 8 : Combinatorics 2 :

The curve described is the Koch snowflake. Let N_n be the number of sides of the curve P_n. At step 0, $N_0 = 3$ sides and its area is $S_0 = 1$. The number of sides is multiplied by 4 at each iteration: $N_n = 3 \times 4^n$. The area of a small triangle constructed at step $n+1$ is $\frac{1}{9^{n+1}}$. The total area S_n after n steps is the sum:

$$S_n = S_0 + \sum_{k=0}^{n-1} N_k \times \frac{1}{9^{k+1}} = 1 + \sum_{k=0}^{n-1} (3 \times 4^k) \times \frac{1}{9^{k+1}} = 1 + \frac{1}{3} \sum_{k=0}^{n-1} \left(\frac{4}{9}\right)^k$$

The sum is that of a geometric sequence:

$$S_n = 1 + \frac{1}{3} \times \frac{9}{5} \left(1 - \left(\frac{4}{9}\right)^n\right) \implies \mathbf{S_n = \frac{8}{5} - \frac{3}{5} \left(\frac{4}{9}\right)^n}$$

Let's now determine the limit of the sequence $\{S_n\}$. Since $-1 < \frac{4}{9} < 1$, we have $\lim_{n \to \infty} \left(\frac{4}{9}\right)^n = 0$. Consequently: $\lim_{\mathbf{n} \to \infty} \mathbf{S_n} = \frac{8}{5} = \mathbf{1.6}$.

Programming Exam (Python)

Solution P1 : System of Equations:

Let's extract $x = \frac{117 - y^2}{y}$. Solving by finding the zeros of the single-variable function y.

```
def equation_en_y(y):
    if y == 0: return float('inf')
    x = (117 - y**2) / y
    return (x**2) * y - x - 140

def trouver_solutions():
    solutions_y = []
    pas = 0.1
    y = -50.0
    while y < 50.0:
        y_suivant = y + pas
        if abs(y) < 1e-5 or abs(y_suivant) < 1e-5:
            y += pas
            continue
        if equation_en_y(y) * equation_en_y(y_suivant) < 0:
            gauche, droite = y, y_suivant
            for _ in range(50):
                milieu = (gauche + droite) / 2
                if equation_en_y(gauche) * equation_en_y(milieu) < 0: droite = milieu
                else: gauche = milieu
            y_sol = round(milieu, 4)
            if y_sol not in solutions_y: solutions_y.append(y_sol)
        y += pas
```

```
    for i, y_val in enumerate(solutions_y, 1):
        x_val = round((117 - y_val**2) / y_val, 4)
        print(f"Solution {i} -> x = {x_val} ; y = {y_val}")
trouver_solutions()
```

Output: $(4, 9)$ **and** $(-3.2953, 12.5891)$

Solution P2 : Sum of Triangular Numbers:

```
somme_totale = 0
T_k = 0
for k in range(1, 101):
    T_k = T_k + k
    somme_totale = somme_totale + T_k
print("La somme totale cumulée vaut :", somme_totale)
```

Expected Output: 171700

Solution P3 : Intersection of Functions:

```
import math
def f(x):
    if x**5 + 4 < 0: return float('nan')
    return math.sqrt(x**5 + 4)
def g(x): return 12 - 7*x + x**3
def ecart(x):
    val_f = f(x)
    if math.isnan(val_f): return float('nan')
    return val_f - g(x)
def trouver_intersection():
    pas = 0.01
    x = -1.4
    while x < 10.0:
        x_suivant = x + pas
        if not math.isnan(ecart(x)) and not math.isnan(ecart(x_suivant)) and ecart(x) * ecart(x_suivant) < 0
            gauche, droite = x, x_suivant
            for _ in range(50):
                milieu = (gauche + droite) / 2
                if ecart(gauche) * ecart(milieu) < 0: droite = milieu
                else: gauche = milieu
            print(f"Intersection : ({round(milieu, 5)} ; {round(f(milieu), 5)})")
            break
        x += pas
trouver_intersection()
```

Expected Output: (2.0 ; 6.0)

Solution P4 : Decryption of the Safe:

```
def est_premier(n):
    if n < 2: return False
    for i in range(2, int(n**0.5) + 1):
        if n % i == 0: return False
    return True
def chercher_code():
    couples_d1d2 = [n for n in range(10, 50) if est_premier(n) and (n % 10) % 2 != 0 and (n // 10 + n % 10)
    d3 = 6
    paires_d5_d6 = [(6, 2), (4, 3)]
    for d1d2 in couples_d1d2:
        d1, d2 = d1d2 // 10, d1d2 % 10
        d4 = (d1 * 100 + d2 * 10 + d3) % 9
        for d5, d6 in paires_d5_d6:
```

```
            if (d1 + d2 + d3 + d4 + d5 + d6) % 2 != 0:
                code = d1*100000 + d2*10000 + d3*1000 + d4*100 + d5*10 + d6
                if code % 11 == 0: return code
print("Le code est :", chercher_code())
```

Expected Output: 316162

Solution P5 : Triple Recursive Sequence:

```
def f(n):
    if n == 0: return 1
    elif n % 3 == 0: return f(n // 3) + 16
    elif n % 3 == 1: return f(n // 3) - 4
    else: return f(n // 3) + 10
print("f(1000000) =", f(1000000))
```

Expected Output: 99

Solution P6 : Shortest Path (Dijkstra):

```
import heapq
def dijkstra(graphe, depart, arrivee):
    distances = {s: float('inf') for s in graphe}
    distances[depart] = 0
    file = [(0, depart)]
    while file:
        d, u = heapq.heappop(file)
        if u == arrivee: break
        if d > distances[u]: continue
        for v, poids in graphe[u].items():
            if d + poids < distances[v]:
                distances[v] = d + poids
                heapq.heappush(file, (d + poids, v))
    return distances[arrivee]

graphe = {
    "A1": {"A2": 25, "A4": 60}, "A2": {"A1": 25, "A3": 15},
    "A3": {"A2": 15, "A4": 30, "A7": 55}, "A4": {"A1": 60, "A3": 30, "A5": 18, "A9": 80},
    "A5": {"A4": 18, "A6": 22}, "A6": {"A5": 22, "A7": 40, "A10": 45},
    "A7": {"A3": 55, "A6": 40, "A8": 12}, "A8": {"A7": 12, "A9": 28, "A12": 65},
    "A9": {"A4": 80, "A8": 28, "A10": 17}, "A10": {"": 45, "A9": 17, "A11": 25},
    "A11": {"A10": 25, "A12": 30}, "A12": {"A8": 65, "A11": 30}
}
print("Distance minimale :", dijkstra(graphe, "A1", "A12"), "km")
```

Expected Output: 172 km $(A_1 \to A_2 \to A_3 \to A_7 \to A_8 \to A_{12})$.

Solution P7 : Prime Eulerian Product:

```
import math
def est_premier(k):
    if k < 2: return False
    for i in range(2, int(k**0.5) + 1):
        if k % i == 0: return False
    return True
N = 100000
premiers = [i for i in range(2, N + 1) if est_premier(i)]
pi_n = len(premiers)
produit = 1.0
for p in premiers: produit *= (1.0 + 2.0 / (p * (p - 1)))
u_n = (N / (pi_n * math.log(N))) * produit
print(f"u_n converge vers : {u_n:.6f}")
```

Expected Output: 2.969766

Solution P8 : Hydraulic Flow:

```
import math
volume_total, debit_robinet, volume_actuel, temps = 300, 1.8, 0, 0
while volume_actuel < volume_total:
    debit_fuite = 0.05 * math.sqrt(volume_actuel)
    volume_actuel += (debit_robinet - debit_fuite)
    temps += 1
print(f"Le réservoir est plein en : {temps} secondes")
```

Expected Output: 181 secondes.

Programming Exam (C++ Version)

Solution C++ 1 : System of Equations:

```
#include <iostream>
#include <cmath>
#include <vector>
#include <iomanip>
using namespace std;
double equation_en_y(double y) {
    if (abs(y) < 1e-9) return 1e9;
    double x = (117.0 - y * y) / y;
    return (x * x) * y - x - 140.0;
}
int main() {
    vector<double> solutions_y;
    double pas = 0.1;
    for (double y = -50.0; y < 50.0; y += pas) {
        if (abs(y) < 1e-5 || abs(y + pas) < 1e-5) continue;
        if (equation_en_y(y) * equation_en_y(y + pas) < 0) {
            double gauche = y, droite = y + pas, milieu = 0;
            for (int i = 0; i < 50; i++) {
                milieu = (gauche + droite) / 2.0;
                if (equation_en_y(gauche) * equation_en_y(milieu) < 0) droite = milieu;
                else gauche = milieu;
            }
            solutions_y.push_back(round(milieu * 10000.0) / 10000.0);
        }
    }
    cout << fixed << setprecision(4);
    for (size_t i = 0; i < solutions_y.size(); i++) {
        double y_val = solutions_y[i];
        cout << "Solution " << i + 1 << " -> x = " << (117.0 - y_val * y_val) / y_val << " ; y = " << 
    }
    return 0;
}
```

Solution C++ 2 : Sum of Triangular Numbers:

```
#include <iostream>
using namespace std;
int main() {
    long long somme_totale = 0, T_k = 0;
    for (int k = 1; k <= 100; k++) {
        T_k += k;
        somme_totale += T_k;
    }
```

```
    cout << "La somme vaut : " << somme_totale << endl;
    return 0;
}
```

Solution C++ 3 : Intersection of Functions:

```
#include <iostream>
#include <cmath>
#include <iomanip>
using namespace std;
double f(double x) { return (pow(x, 5) + 4.0 < 0) ? NAN : sqrt(pow(x, 5) + 4.0); }
double g(double x) { return 12.0 - 7.0 * x + pow(x, 3); }
double ecart(double x) { return isnan(f(x)) ? NAN : f(x) - g(x); }
int main() {
    double pas = 0.01;
    for (double x = -1.3195; x < 10.0; x += pas) {
        if (!isnan(ecart(x)) && !isnan(ecart(x + pas)) && ecart(x) * ecart(x + pas) < 0) {
            double gauche = x, droite = x + pas, milieu = 0;
            for (int i = 0; i < 50; i++) {
                milieu = (gauche + droite) / 2.0;
                if (ecart(gauche) * ecart(milieu) < 0) droite = milieu;
                else gauche = milieu;
            }
            cout << fixed << setprecision(5) << "Intersection : (" << milieu << " ; " << f(milieu) <<
            break;
        }
    }
    return 0;
}
```

Solution C++ 4 : Decryption of the Safe:

```
#include <iostream>
#include <vector>
using namespace std;
bool est_premier(int n) {
    if (n < 2) return false;
    for (int i = 2; i * i <= n; i++) if (n % i == 0) return false;
    return true;
}
int main() {
    vector<int> couples;
    for (int n = 10; n < 50; n++) if (est_premier(n) && (n % 10) % 2 != 0 && (n / 10 + n % 10) == 4) c
    int d3 = 6, p5[2] = {6, 4}, p6[2] = {2, 3};
    for (int c : couples) {
        int d1 = c / 10, d2 = c % 10, d4 = (d1 * 100 + d2 * 10 + d3) % 9;
        for (int i = 0; i < 2; i++) {
            if ((d1 + d2 + d3 + d4 + p5[i] + p6[i]) % 2 != 0) {
                long long code = d1 * 100000 + d2 * 10000 + d3 * 1000 + d4 * 100 + p5[i] * 10 + p6[i];
                if (code % 11 == 0) { cout << "Code : " << code << endl; return 0; }
            }
        }
    }
    return 0;
}
```

Solution C++ 5 : Triple Recursive Sequence:

```
#include <iostream>
#include <map>
using namespace std;
map<long long, long long> memo;
```

```
long long f(long long n) {
    if (n == 0) return 1;
    if (memo.count(n)) return memo[n];
    if (n % 3 == 0) return memo[n] = f(n / 3) + 16;
    if (n % 3 == 1) return memo[n] = f(n / 3) - 4;
    return memo[n] = f(n / 3) + 10;
}
int main() { cout << "f(1000000) = " << f(1000000) << endl; return 0; }
```

Solution C++ 6 : Shortest Path (Dijkstra):

```
#include <iostream>
#include <vector>
#include <string>
#include <map>
#include <queue>
using namespace std;
int main() {
    map<string, map<string, int>> graphe;
    graphe["A1"] = {{"A2", 25}, {"A4", 60}}; graphe["A2"] = {{"A1", 25}, {"A3", 15}};
    graphe["A3"] = {{"A2", 15}, {"A4", 30}, {"A7", 55}}; graphe["A4"] = {{"A1", 60}, {"A3", 30}, {"A5"
    graphe["A5"] = {{"A4", 18}, {"A6", 22}}; graphe["A6"] = {{"A5", 22}, {"A7", 40}, {"A10", 45}};
    graphe["A7"] = {{"A3", 55}, {"A6", 40}, {"A8", 12}}; graphe["A8"] = {{"A7", 12}, {"A9", 28}, {"A12
    graphe["A9"] = {{"A4", 80}, {"A8", 28}, {"A10", 17}}; graphe["A10"] = {{"A6", 45}, {"A9", 17}, {"A
    graphe["A11"] = {{"A10", 25}, {"A12", 30}}; graphe["A12"] = {{"A8", 65}, {"A11", 30}};
    map<string, int> dist;
    for (int i = 1; i <= 12; i++) dist["A" + to_string(i)] = 1e9;
    dist["A1"] = 0;
    priority_queue<pair<int, string>, vector<pair<int, string>>, greater<pair<int, string>>> pq;
    pq.push({0, "A1"});
    while (!pq.empty()) {
        int d = pq.top().first; string u = pq.top().second; pq.pop();
        if (u == "A12") break;
        if (d > dist[u]) continue;
        for (auto const& v : graphe[u]) {
            if (d + v.second < dist[v.first]) { dist[v.first] = d + v.second; pq.push({dist[v.first],
        }
    }
    cout << "Distance : " << dist["A12"] << " km" << endl; return 0;
}
```

Solution C++ 7 : Prime Eulerian Product:

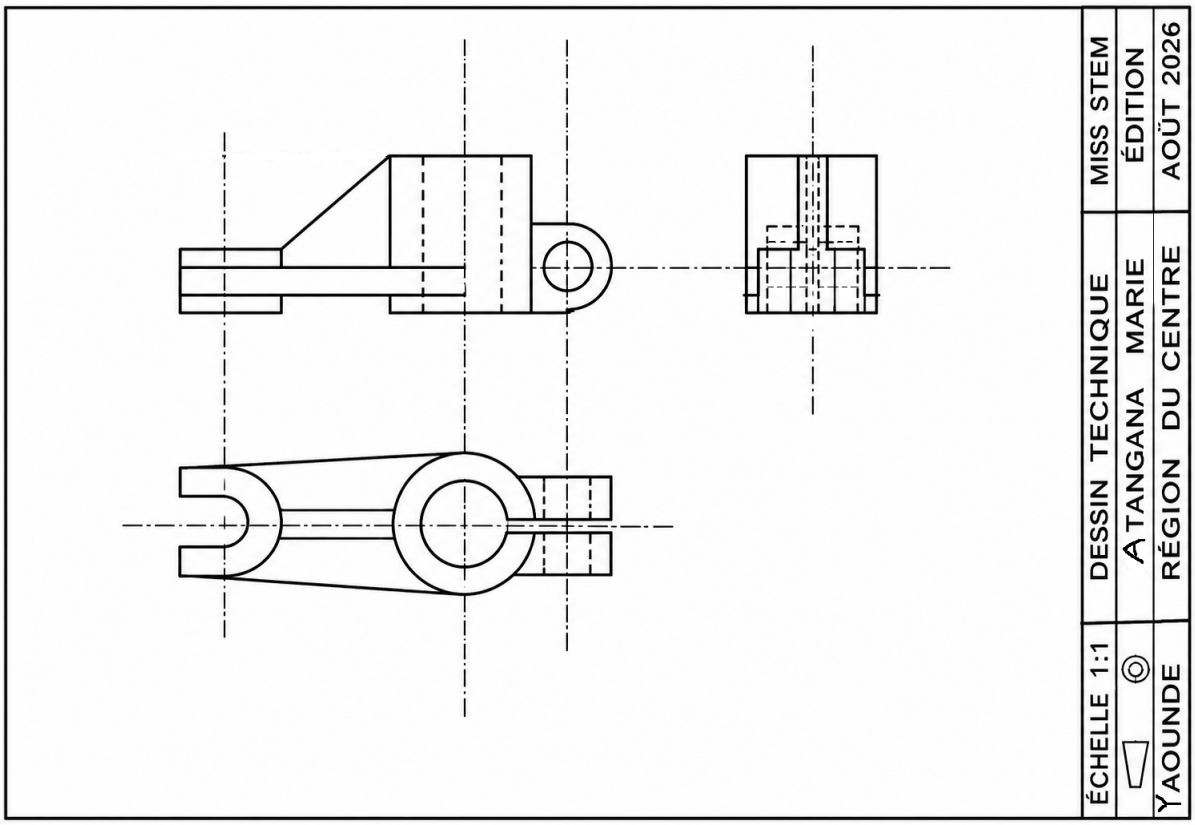
```
#include <iostream>
#include <vector>
#include <cmath>
#include <iomanip>
using namespace std;
bool is_p(int k) {
    if (k < 2) return false;
    for (int i = 2; i * i <= k; i++) if (k % i == 0) return false;
    return true;
}
int main() {
    int N = 100000; double produit = 1.0; int pi_n = 0;
    for (int i = 2; i <= N; i++) {
        if (is_p(i)) { pi_n++; produit *= (1.0 + 2.0 / (i * (i - 1.0))); }
    }
    cout << fixed << setprecision(6) << "u_n = " << (N / (pi_n * log(N))) * produit << endl;
    return 0;
}
```

Solution C++ 8 : Hydraulic Flow:

```
#include <iostream>
#include <cmath>
using namespace std;
int main() {
    double v_tot = 300.0, d_rob = 1.8, v_act = 0.0; int t = 0;
    while (v_act < v_tot) { v_act += (d_rob - 0.05 * sqrt(v_act)); t++; }
    cout << "Temps : " << t << " secondes" << endl; return 0;
}
```

Technical Drawing Section

We provide the representation of views for the first part. We leave it to the candidates to work on the second part themselves.



Technological Text Comprehension Section

Q1 : B	**Q2 : C**	**Q3 : A**	**Q4 : C**	**Q5 : C**
Q6 : B	**Q7 : A**	**Q8 : C**	**Q9 : B**	**Q10 : B**

Logical Explanations for the Questions:

Q11 (B) : *Deductive.* Peak demand = 1400 MW. Available power in dry season = 1100 MW. $1400-1100 = 300$ MW critical deficit.

P12 (C) : *Deductive.* Stepping up the voltage decreases the current intensity (I) at equal power, drastically reducing losses by Joule heating ($P = R \cdot I^2$).

Q13 (C) : *Deductive.* Max flow rate = 980 m^3/s. For 1 minute (60s): $980 \times 60 = 58\,800$ m^3.

Q14 (C) : *Deductive.* They retain water during the rainy season to support the flow rate during low-water periods, regulating the upstream flow.

Q15 (C) : *Deductive.* Since the incident energy (0.95 eV) is lower than the bandgap of Silicon (1.12 eV), no electrons are released.

Q16 (C) : *Deductive.* The panels generate direct current (DC); the inverter transforms it into alternating current (AC) synchronous with the 50 Hz grid.

Q17 (B) : *Deductive.* Cogeneration simultaneously recovers electrical energy via the turbine and thermal/calorific energy via residual steam heat.

Q18 (C) : *Deductive.* The text specifies the removal of "corrosive H_2S", protecting the internal components of the thermal engine.

Q19 (C) : *Deductive.* Measuring phase and amplitude at high frequency provides ultra-fast dynamic mapping of the grid's stability state to prevent widespread blackouts.

Q20 (B) : *Deductive.* This ultra-high-voltage transmission line will structurally connect the South (SIG) and the North (NIG), unifying the national energy mix.

Concluding Note and Future Perspectives

Dear candidates, teachers, and partners of the scientific community,

This preparation booklet, carefully designed by the organizing committee of the **MISS STEM Cameroon 2026** competition, has come to an end. Through the exams presented, whether dealing with the subtlety of angle chasing in geometry, pure algorithmic logic, or the analysis of smart energy grids in our country, a fundamental message remains: **sciences are not mere abstractions, they are the technological levers of our future sovereignty**.

The ambition of this program goes far beyond simple academic selection. It aims to foster a new generation of female leaders ready to design, build, and lead the industrial Cameroon of tomorrow. Faced with the complexity of such a demanding scientific tetrathlon, do not shrink from any grey area. View every difficulty as the starting point for acquiring a new skill.

We would like to express our warmest thanks to the regional delegations, the members of the general secretariat of **PROMO-MATHS**, as well as our academic and industrial partners who join forces to make this adventure a resounding success.

To all the high school girls who are about to compete: audacity is the primary quality of an engineer. Fly high the colors of your division, your region, and science. May this booklet be the springboard for your success.

The Organizing Committee
MISS STEM Cameroon 2026

The President of PROMO-MATHS
Adrien BENYOMO