International Computer Science Competition

Solutions for Example Problems (Qualification Round)

Example Problem 1

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Question 1: Which one of the following is definitely true?

The first requirement is that every job must have someone assigned to it. Therefore, Ananya must take on the role of manager. The second requirement is that each person can only hold one position. Since only Ananya and Mustafa are qualified for the serving role, and Ananya is already assigned as manager, Mustafa must be the server.

Therefore, the correct answer is c).

Question 2: Which one of the following cannot be true?

Ananya is hired as the manager and Mustafa as the cleaner. According to the first requirement, every job must have someone assigned to it. That means we still need someone for the server role. However, only Mustafa and Ananya are qualified for the server rule. Based on the second requirement, that each person can only hold one position, and with Ananya and Mustafa already assigned, there's no one left who can serve. Therefore, this option cannot be valid.

Therefore, the correct answer is b).

Solution to Example Problem 2

Implementation

Below is the implementation of Algorithm A in Python[1]:

```python
import random
import sys  # Needed for stderr printing and exit

def algorithm_a(num_points: int) -> float:
    points_in_circle = 0

    for i in range(num_points):
        # Generate random x and y between -1 and 1
        x = random.uniform(-1, 1)
        y = random.uniform(-1, 1)

        # Check if the point is inside the unit circle
        if x**2 + y**2 <= 1:
            points_in_circle += 1

    # Calculate and return the result
    return 4 * (points_in_circle / num_points)

```

Explanation

Algorithm A computes an approximation of the mathematical constant π using a method known as Monte Carlo simulation. The algorithm works in four steps:

1. The algorithm generates a specified number of random points within a 2×2 square centered at the origin (with x and y coordinates between -1 and 1).
2. For each generated point, it checks whether the point falls inside the unit circle (a circle with radius 1 centered at the origin). The condition $x^2 + y^2 \leq 1$ uses the Pythagorean theorem to determine if a point is inside the circle.
3. It keeps track of how many points fall inside the circle.
4. Finally, it calculates 4 times the ratio of points inside the circle to the total number of points generated.

What would make this solution outstanding?

An outstanding submission could include a clear explanation of the mathematical reasoning behind the final calculation (i.e., why the method computes $4 \times \frac{\text{points in circle}}{\text{num points}}$). Another way to enhance the submission would be to discuss the behavior of this approximation method when increasing the number of points.

[1] Since the function `main()` should not be modified, it also does not need to be included on your solution document as it is not part of your solution.