AddisCoder Quiz 2

Congrats on completing Week 2! 🥳

You will have **2 hours** to complete this written quiz. You may use any method to solve a problem unless it explicitly asks for a recursive solution. The questions are not necessarily in order of difficulty.

Please write your **full name** and **lab number** (NB111, NB112, NB114, Green Lab, or Brown Lab) on the first page of the quiz.

This quiz will cover material from weeks 1 and 2, including:

- Conditionals and Loops
- Lists and Dictionaries
- Functions
- Recursion
- Images

Problem 1: Report Card Day! (Dictionaries) 📝

1.1 Create an empty dictionary named `report_card`.

1.2 To the `report_card` dictionary, add the following key-value pairs:

`"Maths" -> 95`

SOLUTION

```
1.1  report_card = {}

1.2  report_card["Maths"] = 95
     report_card["Physics"] = 88
     report_card["Chemistry"] = 92
```

1.3 You aced the Math final! Change the value of `"Maths"` to `100` in the `report_card` dictionary, and print the updated dictionary.

SOLUTION

```
1.3  report_card["Maths"] = 100
     print(report_card)  # {"Maths": 100, "Physics": 88, "Chemistry": 92}
```

1.4 Using the `report_card` dictionary, print your grade in Chemistry class.

SOLUTION

```
1.4  print(report_card["Chemistry"])  # 92
```

Problem 2: Mutation Mayhem (Lists and Dictionaries) 📖

2.1 What is the **printed output** of the following code?

```
A = [[2], 12, [[4], 6], 8, 10]

B = A
B.pop()

A[2][1] = 9
A[0] += [7]

print(A)
print(B)
```

SOLUTION

```
2.1 Output:
[[2, 7], 12, [[4], 9], 8]
[[2, 7], 12, [[4], 9], 8]
```

2.2 What is the **printed output** of the following code?

```
sales = {"Bunna": 30, "Shai": 15, "Mrinda": 55}

sales["Mrinda"] = sales["Bunna"] + 20
removed = sales.pop("Shai")
sales["Milk"] = removed + sales["Mrinda"]
sales["Bunna"] -= 5

print(sales)
```

SOLUTION

```
2.2 Output:
{"Bunna": 25, "Mrinda": 50, "Milk": 65}
```

Problem 3: Loopy Logic (Print with Loops) 🔁

3.1 What is the **printed output** of the following code?

```
for i in range(2 ** 2 - 4 // 2):
    x = i + 1
    if x <= 5:
        print(i + 1 * 2)
```

```
Output:
```

SOLUTION

```
3.1 Output:
2
3
```

3.2 What is the **printed output** of the following code?

```
for i in range(2, 5, 2):
  line = str(i) + ": "

  for j in range(1, i+1):
    if i % j == 0:
      line += str(j) + " "
  print(line)
```

SOLUTION

```
3.2 Output:
2: 1 2
4: 1 2 4
```

Problem 4: Dictionary Building 📚

4.1 Write a function `word_length(word)` that takes a single string `word` and returns the number of letters in the word.

Example:

`word_length("injera") -> 6`

`word_length("teff") -> 4`

Here, `"injera"` has 6 letters, so the function returns `6`. Similarly, `"teff"` has 4 letters, so the function returns `4`.

SOLUTION

```
4.1
def word_length(word):
    return len(word)
```

4.2 Write a function `group_by_length(words)` that takes a list of strings `words` and returns a dictionary where:

- The keys are the lengths of the words.
- The values are lists of words that have that length.

Example:

`group_by_length(["injera", "teff", "kitfo", "shiro", "tibs"]) -> {6: ["injera"], 4: ["teff", "tibs"], 5: ["kitfo", "shiro"]}`

Here, `injera` has 6 letters, so it is grouped under the key `6`. Both `teff` and `tibs` have 4 letters, so they are grouped together under key `4`. Similarly, `kitfo` and `shiro` each have 5 letters and are grouped under key `5`.

SOLUTION

```
4.2
def group_by_length(words):
    groups = {}
    for word in words:
        length = word_length(word)
        if length not in groups:
            groups[length] = []
        groups[length].append(word)
    return groups
```

Problem 5: Find the Black Pixel 🕵️

5.1 What is the **printed output** of the following code?

The image below is a 5×5 grid where all pixels are white except for one black pixel (RGB = 0, 0, 0).

Write a function `find_black_pixel(img)` that takes an image of arbitrary size that contains exactly one black pixel and returns the `(x, y)` coordinates of the black pixel.

You can assume:

- The input image is square (N×N) and can be of any size.
- The image contains exactly one black pixel. (Not necessarily in the same spot as the example)
- All other pixels are white (RGB = 255, 255, 255).

Hint: You can use `img.width` and `img.height` to get width and height of the input image.

SOLUTION

```
5.1
def find_black_pixel(img):
    for y in range(img.height):
        for x in range(img.width):
            pixel = img.get_pixel(x, y)
            if pixel.red == 0 and pixel.green == 0 and pixel.blue == 0:
                return (x, y)
```

Problem 6: Filters Galore 🌈

Consider the following code that inverts the colors of an image using the SimpleImage library.

```
from simpleimage import SimpleImage

def invert(img):
    for pixel in img:
        pixel.red = 255 - pixel.red
        pixel.green = 255 - pixel.green
        pixel.blue = 255 - pixel.blue
```

Suppose you run this code twice in a row on the same image:

```
image = SimpleImage("assets/einstein.jpeg")
invert(image)
invert(image)
```

What will the final image look like? Select one of option below.

- ○ A. It will be all white
- ○ B. It will be the negative (color-inverted) version of the original image
- ○ C. It will be back to the original image
- ○ D. It will be all black

SOLUTION

6. Answer: C. It will be back to the original image.

Each channel is transformed twice: 255 - (255 - value) = value.

Problem 7: Product Puzzle 🧩

7.1 What is the **printed output** of the following code?

```
def puzzle_product(x):
    result = 1
    for i in x:
        result *= i
    return result

def fun_func(x):
    result = []
    for i in x:
        result += [puzzle_product(i)]
    return result

print(fun_func([[1,2,3],[2,3,4],[3,4,5]]))
```

Answer: _____

SOLUTION

```
7.1 Answer: [6, 24, 60]

The inner lists have products 1*2*3 = 6, 2*3*4 = 24,
and 3*4*5 = 60.
```

Problem 8: Self-Dividing Numbers 🔢

A self-dividing number is an integer `n` that:

- contains no digit 0 and
- is divisible by every one of its digits.

Example:

- 128 is self-dividing → 128 is divisible by 1, 128 is divisible by 2, and 128 is also divisible by 8
- 26 is not self-dividing → digit 6 does not divide 26

8.1 First, write a function called `digits_of(n)` that returns the list of decimal digits of `n` (in any order).

Example:

```
digits_of(128) → [1, 2, 8]
digits_of(26) → [2, 6]
```

SOLUTION

```
8.1
def digits_of(n):
    digits = []
    while n > 0:
        digits.append(n % 10)
        n //= 10
    return digits

# The problem permits the digits in any order.
```

8.2 Using your `digits_of(n)` function from Problem 8.1, write a function called `is_self_dividing(n)` that returns `True` if `n` is a self-dividing number, and `False` otherwise.

Examples:

`is_self_dividing(128)` → `True` since digits: [1, 2, 8]; 128 is divisible by all

`is_self_dividing(26)` → `False` since digits: [2, 6]; 26 is not divisible by 6

`is_self_dividing(101)` → `False` since digits: [1, 0, 1]; contains a 0 → not self-dividing

SOLUTION

```
8.2
def is_self_dividing(n):
    for digit in digits_of(n):
        if digit == 0 or n % digit != 0:
            return False
    return True
```

8.3 Write a function `print_self_dividing(n)` that prints every self-dividing number from `1` to `n` (inclusive), one per line. You can use the functions you wrote in the previous subproblems.

SOLUTION

```
8.3
def print_self_dividing(n):
    for number in range(1, n + 1):
        if is_self_dividing(number):
            print(number)
```

Problem 9: Debugging 🐞

The code below crashes with the error: `TypeError: unsupported operand type(s) for *: 'int' and 'NoneType'`

```
def factorial(n):
    if n == 0:
        return
    return n * factorial(n - 1)

factorial(5)
```

Circle the line of code with the bug in it. Then, rewrite that line of code to fix the bug.

Answer: _____

SOLUTION

9. Buggy line: return

Correct line:

```
    return 1
```

The base case must return 1 so multiplication has a numeric value.

Problem 10: Recursion

The following is a recursive function that takes a list of numbers as an argument and returns a single number.

```
def mystery_function(numbers):
    if len(numbers) == 0:
        return 0
    else:
        last_number_sq = numbers[-1] ** 2
        numbers.pop() # remove last number
        value = mystery_function(numbers)

        if last_number_sq % 2 == 0:
            return value + last_number_sq
        else:
            return value
```

10.1 Circle the **base case** of the function.

10.2 In your own words, explain what the function `mystery_function` does.

Answer:

SOLUTION

10.1 Base case: if len(numbers) == 0: return 0

10.2 It removes every number, squares it, and returns the sum of only the even squares (equivalently, the squares of the even inputs).

10.3 Output: 20 (4**2 + 2**2)

Problem 11: Recursion Tracing 🔍

```
def shout(n):
   print("Shout!")
   if n > 1:
       shout(n - 1)
       shout(n - 2)
```

11.1 How many times is `Shout!` printed when `shout(2)` is called?

Answer: _____

SOLUTION

11.2 How many times is `Shout!` printed when `shout(3)` is called?

Answer: _____

SOLUTION

Problem 12: Recursion Debugging 💻

```
def nested_list_sum(lst):
    s = 0
    for x in lst:
        if type(x) == int:
            s += x
        else:
            nested_list_sum(x)
    return s
```

The function above is meant to compute the sum of all integers in a (possibly nested) list. However, `nested_list_sum([1, 2, 3, [4, 5]])` returns `6` instead of the correct result `15`. **Circle the buggy line and rewrite it with the correct code.**

SOLUTION

```
12. Buggy line: nested_list_sum(x)
Correct line: s += nested_list_sum(x)
```

Answer: _____

Problem 13: Recursively Remove All Digits 🔢

Write a recursive function `remove_digits(s)` that removes all numeric digits from the string `s`.

Example:

`remove_digits("a1b2c3") → "abc"`

`remove_digits("123abc") → "abc"`

`remove_digits("no digits") → "no digits"`

Hint: You can use the function `isdigit()` to check if a string consists entirely of digits. For example, `"10013".isdigit()` and `"4".isdigit()` return `True`. On the other hand, `"abc".isdigit()` and `"ab2c".isdigit()` return `False`, since they contain non-digit characters.

⚠️ Restrictions: You must use recursion. You **cannot** use any loops (for or while).

SOLUTION

```
13.
def remove_digits(s):
    if s == "":
        return ""
    rest = remove_digits(s[1:])
    if s[0].isdigit():
        return rest
    return s[0] + rest
```

Problem 14: Sum Cubes of Even Numbers... Using Recursion!

Write a function `sum_cubes_even(n)` that recursively computes the sum of the cubes of all even numbers from 1 up to and including `n`, if n is even. If `n` is odd, include only even numbers less than `n`.

You are guaranteed that `n` is a positive integer.

Mathematically, the function should evaluate:

$2^3 + 4^3 + 6^3 + \cdots + m^3$ → where m is the largest even number less than or equal to n.

⚠️ Restrictions: You must use recursion. You **cannot** use any loops (for or while).

Example:

`sum_cubes_even(5) = 72` because: $2^3 + 4^3 = 8 + 64 = 72$ → m is 4 in this case, which is the largest even number less than or equal to 5

`sum_cubes_even(6) = 288` because: $2^3 + 4^3 + 6^3 = 8 + 64 + 216 = 288$ → m is 6, which is equal to n.

`sum_cubes_even(1) = 0` (no even numbers up to 1)

SOLUTION

```
14.
def sum_cubes_even(n):
    if n < 2:
        return 0
    if n % 2 == 1:
        return sum_cubes_even(n - 1)
    return n ** 3 + sum_cubes_even(n - 2)
```

Bonus Problem ✨

This problem is not counted towards the quiz. Only answer it if you answered everything else.

How many times is `"Hello"` printed when the following code is run?

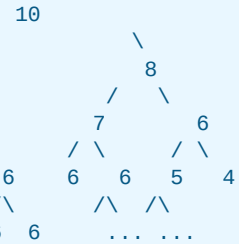
```
def fun(x):
    if x == 0:
        return
    if x%2 == 0:
        print("Hello")
        fun(x-1)
        fun(x-2)
    else:
        fun(x-1)
        fun(x-1)

fun(10)
```

Answer: _____

SOLUTION

Bonus answer: 121 times

Partial call tree:



Compressing each odd call shows that every even value creates three calls two numbers lower:

```
10 -> depth 0:  1
 8 -> depth 1:  3
 6 -> depth 2:  9
 4 -> depth 3: 27
 2 -> depth 4: 81
```

Total Hello prints = 1 + 3 + 9 + 27 + 81 = 121