C200 Programming Assignment № 2

Functions, Containers, Choice
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In this homework, you'll write functions and use choice. **As always, all the work should be with you and your partner; but *both* of you should contribute.** You must complete this before DUE DATE (February, 10, Thursday, 10:59 PM). You will submit your work by committing your code to your GitHub repository. Please remember that

- you will *not* turn anything in on canvas.
- you do **not manually upload files** to your repository using GitHub's "Upload files" tool.

If your timestamp is 11:01PM or later, the homework will not be graded. So do not wait until 10:59PM to commit and push your changes. If you have any questions about or problems with version control, please visit office hours or make a post on Inscribe. Since you are working in pairs, your paired partner is shown in this week's PAIRS link.

Some of these problems were taken or inspired by the excellent introductory *Applied Calculus* by Tan, 2005.

Problem 1: Choice

Assume g is a real-valued function defined as:

$$g(x) = \begin{cases} x+2 & \text{if } x \neq 0 \\ 1 & \text{if } x = 0 \end{cases} \tag{1}$$

For example,

$$g(0) = 1 \tag{2}$$

$$g(1) = 2 \tag{3}$$

$$g(1.01) = 3.01 \tag{4}$$

Deliverables Problem 1

- Complete the g function

Problem 2: Senior Citizen Health Care

According to a study of the out-of-pocket cost to senior citizens for health care, $f(t)$ (as percent of income), in year t where $t = 0$ corresponds to 1977, is given by:

$$f(t) = \begin{cases} \frac{2}{7}t + 12 & \text{if } 0 \leq t \leq 7 \\ t + 7 & \text{if } 7 < t \leq 10 \\ \frac{3}{5}t + 11 & \text{if } 10 < t \leq 20 \end{cases} \tag{5}$$

We will change this slightly to make it easier on the user. First, we'll assume $t \in [1977, 1997]$. This means t must be in this interval, we then use $t - 1977$. Second, if $t \notin [1977, 1997]$, then we return a string "error: year". The new function definition is:

$$f(t) = \begin{cases} \frac{2}{7}(t - 1977) + 12 & \text{if } 1977 \leq t \leq 1984 \\ (t - 1977) + 7 & \text{if } 1984 < t \leq 1987 \\ \frac{3}{5}(t - 1977) + 11 & \text{if } 1987 < t \leq 1997 \\ \text{“error: year”} & \text{otherwise} \end{cases} \tag{6}$$

For example,

$$\begin{aligned} f(1976) &= \text{“error: year”} \\ f(1977) &= 12.0 \\ f(1985) &= 15 \\ f(1988) &= 17.6 \\ f(2000) &= error : year \end{aligned}$$

Deliverables Problem 2

- Complete the function.

Problem 3: Cost of OEM parts *vs.* non-OEM parts

The cost of OEM parts for year $t = 0$, year $t = 1$, and year $t = 2$ is given by:

$$h_0(t) = \frac{110}{(1/2)t + 1} \tag{7}$$

The cost of non OEM parts for the same years is given by:

$$h_1(t) = 26((1/4)t^2 - 1)^2 + 52 \tag{8}$$

The function that describes the difference between the costs for $t = 0, 1, 2$ is:

$$h(t) = h_0(t) - h_1(t) \tag{9}$$

For example,

$$h(0) = \$32.00 \tag{10}$$
$$h(1) \approx \$6.71 \tag{11}$$
$$h(2) = \$3.00 \tag{12}$$

Deliverables Problem 3

- Complete h_0, h_1, h functions.

Problem 4: Quadratic Formula

The root of an equation are values that make it zero. For example,

$$\begin{aligned} x^2 - 1 &= 0 && (13) \\ (x-1)(x+1) &= 0 && (14) \end{aligned}$$

Then $x = 1$ or $x = -1$ makes eq. 13 zero. Let's verify this. Taking $x = 1$

$$1^2 - 1 = 1 - 1 = 0 \qquad (15)$$

For a quadratic (input variable is a power of two), there will be two roots. We'll consider complex numbers later–for now, we'll assume the roots exist as real numbers. You learned that for a quadratic $ax^2 + bx + c = 0$, two roots x_1, x_2 can be determined:

$$\begin{aligned} x_1 &= \frac{-b + \sqrt{b^2 + 4ac}}{2a} && (16) \\ x_2 &= \frac{-b - \sqrt{b^2 + 4ac}}{2a} && (17) \end{aligned}$$

For $x^2 - 1$ the coefficients are $a = 1, b = 0, c = -1$. Then

$$\begin{aligned} x_1 &= \frac{-0 + \sqrt{0^2 - 4(1)(-1)}}{2(1)} && (18) \\ - &= \frac{\sqrt{4}}{2} = \frac{2}{2} = 1 && (19) \\ x_2 &= \frac{-0 - \sqrt{0^2 - 4a(1)(-1)}}{2(1)} && (20) \\ &= \frac{-\sqrt{4}}{2} = \frac{-2}{2} = -1 && (21) \end{aligned}$$

We can report the pair of roots as (1,-1) where the left value is the larger of the two. We will assume the three values are given as a tuple (a, b, c).

$$q((a,b,c)) = \left(\frac{-b + \sqrt{b^2 - 4ac}}{2a}, \frac{-b - \sqrt{b^2 - 4ac}}{2a}\right) \qquad (22)$$

For example, we'll use $x^2 - 1$, $6x^2 - x - 35$, and $x^2 - 7x - 7$:

$$\begin{aligned} q((1,0,-1)) &= (1.0, -1.0) && (23) \\ q((6,-1,-35)) &= (2.5, -2.3333333333333335) && (24) \\ q((1,-7,-7)) &= (7.887482193696061, -0.8874821936960613) && (25) \end{aligned}$$

Deliverables Problem 4

- Complete the quadratic function.
- You can not use the cmath module for this problem.

Problem 5: AI Grading System

You are writing an AI system to help students in arithmetic. Students are given an expression for example: $5 \times 5 =$ and a corresponding answer for example: 4. The function determines if the answer is the correct output of the given operation or not. There are four operations: multiplication, addition, subtraction, and division. The data is in the form of a list:

$$[arg_1, op, arg_2, answer]$$

$arg_1, arg_2, answer$ are floats and op is a string "*", "+", "-", "/". For example, [1,"*",2,3] which is $1 * 2 = 3$. This expression is False.

The function takes the data list and returns True or False. We'll assume the arguments and answer are the correct type.

$$eq([arg_1, op, arg_2, answer]) = \begin{cases} \text{True} & \text{if } arg_1 \; op \; arg_2 \; = \; answer \\ \text{False} & \text{otherwise} \end{cases} \tag{26}$$

Here are some examples:

$$eq([14, \text{"/"}, 2, 7]) = \text{True} \tag{27}$$

$$eq([20, \text{"*"}, 19, 381]) = \text{False} \tag{28}$$

Deliverables Problem 5

- Complete the function.
- You do not have to account for the zero devision error. We won't check for divide by zero case for division operation.

Problem 6: Switches

In Fig. 1 are a collection of open switches. Electricity travels from the start to end only if the path has closed switches. We use 1,0 to indicated the switches are closed or open, respectively. A list $[s_0, s_1, s_2, s_3, s_4]$ indicates the switch and whether it is opened or closed. $[1, 0, 1, 0, 0]$ means switches 0 and 2 are closed. This means electricity can flow from start to end. Our function $path$ takes a list and returns True if there's a path from start to end and False otherwise.

$$path(list) \quad = \quad \begin{cases} \text{True} & \text{if path} \\ \text{False} & \text{otherwise} \end{cases} \tag{29}$$

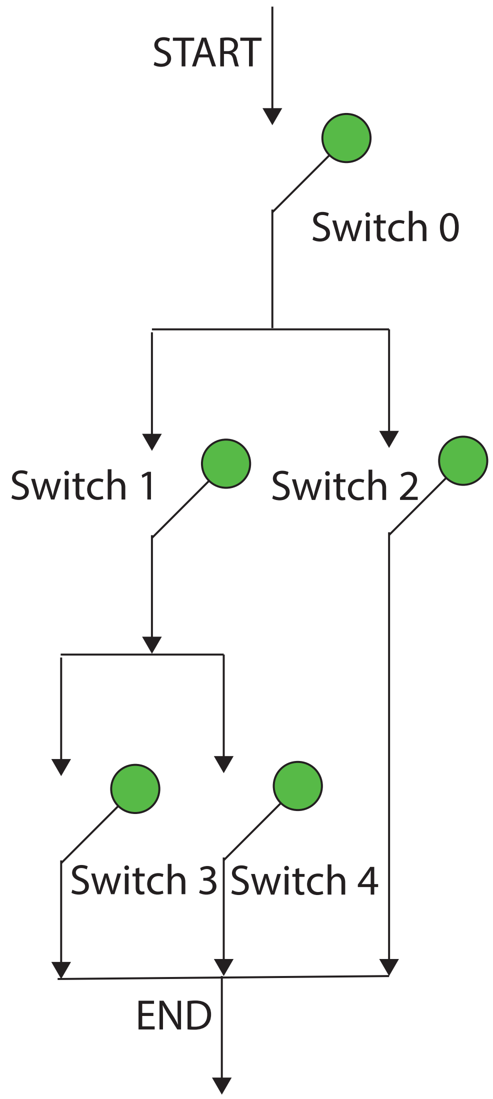

Figure 1: Series of five switches (green). Electricity must travel from start to end. All the switches are off.

For example,

$$
\begin{aligned}
path([1,0,1,0,0]) &= \text{True} \quad (30)\\
path([1,1,1,0,0]) &= \text{True} \quad (31)\\
path([1,0,0,1,0]) &= \text{False} \quad (32)
\end{aligned}
$$

Deliverables Problem 6

- Complete the function

Problem 7: maximum

Write a function max2d that takes two numbers and returns the larger. Using only max2d write a function max3d that takes three numbers and returns the largest.

$$max2d(x, y) = \begin{cases} x & \text{if } x > y \\ y & \text{otherwise} \end{cases} \quad (33)$$

$$max3d(x, y, z) = max2d(x, max2d(y, z)) \quad (34)$$

For example,

$$max3d(1, 2, 3) = 3 \quad (35)$$

$$max3d(1, 3, 2) = 3 \quad (36)$$

$$max3d(3, 2, 1) = 3 \quad (37)$$

Deliverables Problem 7

- Complete both max2d, max3d
- You cannot use Python max()
- You can only use if statements
- max3d can only use max2d

Interestingly, you can use arithmetic and Boolean values for max2d (you cannot use it for this homework)

```python
def m(x,y):
    return (x > y)*x + (x <= y)*y

print(m(1,2))
print(m(2,1))
```

Has output:

```
2
2
```

Student Pairs

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