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 (September 22, 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. Please contact your partner in a professional, courteous way as we have discussed.

Some of these problems were taken or inspired by several excellent, older college texts that I can tell you about later.

Problem 1: Choice

Assume g is a real-valued function defined as:

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

For example,

$$g(0) = 1 \quad (2)$$

$$g(1) = 3 \quad (3)$$

$$g(1.01) = 3.01 \quad (4)$$

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,

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

Deliverables Problem 2

- Complete the f 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 roots of an equation are values that make it zero. For example,

$$x^2 - 1 = 0 \quad (13)$$

$$(x-1)(x+1) = 0 \quad (14)$$

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

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

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:

$$x_1 = \frac{-b + \sqrt{b^2 - 4ac}}{2a} \quad (16)$$

$$x_2 = \frac{-b - \sqrt{b^2 - 4ac}}{2a} \quad (17)$$

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

$$x_1 = \frac{-0 + \sqrt{0^2 - 4(1)(-1)}}{2(1)} \quad (18)$$

$$= \frac{\sqrt{4}}{2} = \frac{2}{2} = 1 \quad (19)$$

$$x_2 = \frac{-0 - \sqrt{0^2 - 4a(1)(-1)}}{2(1)} \quad (20)$$

$$= \frac{-\sqrt{4}}{2} = \frac{-2}{2} = -1 \quad (21)$$

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).

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

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

$$q((1, 0, -1)) = (1.0, -1.0) \quad (23)$$

$$q((6, -1, -35)) = (2.5, -2.3333333333333335) \quad (24)$$

$$q((1, -7, -7)) = (7.887482193696061, -0.8874821936960613) \quad (25)$$

Tip: Square roots can be easily done in Python-think of how to use the '**' operation to find square roots. You want to raise it to a suitable number. For example, if we want to find square of x in Python, then we write x**2, cube of x is done like x**3. So, how do you find square root of x?

Deliverables Problem 4

- Complete the quadratic function q.
- Round the value of roots to two decimal places.
- You cannot use the cmath or math 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.

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

Here are some examples:

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

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

Deliverables Problem 5

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

Problem 6: Switches

Fig-**??** show a series of **open** switches. Electricity travels from the start to end only if the path has closed switches. We use 1, 0 to indicate 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, for example $[1, 0, 1, 0, 0]$ means switches s_0 and s_2 are closed and other switches are open. This means electricity can flow from the start through s_0 and through s_2 to the end. Our function $path$ takes a list which indicats the status of each switch *i.e.,* if it is open or closed, and returns True if there's a path from start to end and False otherwise. In other words, the function simply return True if the electricity can travel from start till the end, otherwise return False.

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

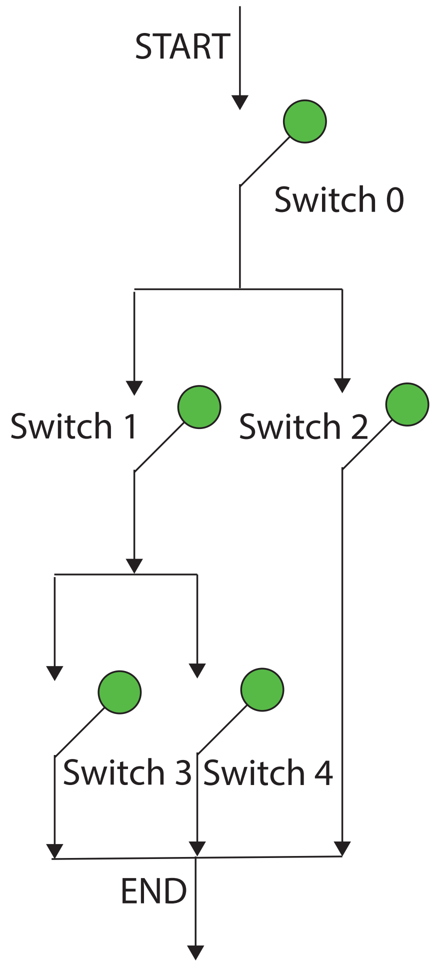

Figure 1: Series of five switches (green). Electricity must travel from start to end. All the switches are off.

For example,

$$path([1,0,1,0,0]) = \text{True} \tag{30}$$
$$path([1,1,1,0,0]) = \text{True} \tag{31}$$
$$path([1,0,0,1,0]) = \text{False} \tag{32}$$

Deliverables Problem 6

- Complete the function path.

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.

$$
\begin{aligned}
max2d(x,y) &= \begin{cases} x & \text{if } x > y \\ y & \text{otherwise} \end{cases} && (33) \\
max3d(x,y,z) &= max2d(x, max2d(y,z)) && (34)
\end{aligned}
$$

For example,

$$
\begin{aligned}
max3d(1,2,3) &= 3 && (35) \\
max3d(1,3,2) &= 3 && (36) \\
max3d(3,2,1) &= 3 && (37)
\end{aligned}
$$

Deliverables Problem 7

- Complete both max2d, max3d functions.
- max2d should only use if-elif-else and comparison operators ">, <, >=, <=".
- You **cannot** use Python max().
- max3d should only use max2d and if statement.

Problem 8: Determining the side and fence

You are writing code for a landscaping company. Typically people want a rectangular backyard of area A. Let x denote one dimension of the rectangle and y the other. Write a Python program which, when given the area (A) and one side of the rectangle (x) will determine the other side (y), and also the total amount of fence needed. In particular, the function 'g_' should return the length of the other side (y), and function 'f_' should return the amount of fence needed.

For example, if someone wanted a fence for $250\,\text{ft}^2$ using $x = 10\,\text{ft}$, then the total amount of fence must be $70.0\,\text{ft}$ and $y = 25.0\,\text{ft}$. We can verify this, because $xy = 250\,\text{ft}$ and $2x + 2y = 70.0\,\text{ft}$. If $x = 20\,\text{ft}$, then the fence must be $65.0\,\text{ft}$ and $y = 12.5\,\text{ft}$. You will write two functions, f and g.

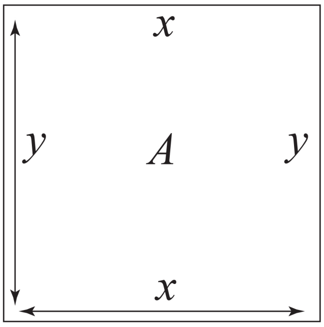

Figure 2: The dimensions of a rectangular $x \times y$ fence.

Deliverables Problem 8

- Complete the functions f_ and g_.

Problem 9: Determining Cost

A rectangular box has a square base, where the width and length is x ft and the sides are y ft tall. The total volume of the box should be $20\,\mathrm{ft}^3$. Here are the costs:

base	$\$.30\,PER$ ft^2
top	$\$.20\,PER$ ft^2
sides	$\$.10\,PER$ ft^2

Write a Python program to determine the total cost of constructing the box as a function of x. For example, if $x = 2\,\mathrm{ft}$, then $y = 5\mathrm{ft}$, and the cost will be $6.00.

Tip: y can be found because you already know the total volume of the box. Once you have x and y, they can be used to calculate the total cost. Remember the table that is given is for cost per square feet i.e. area.

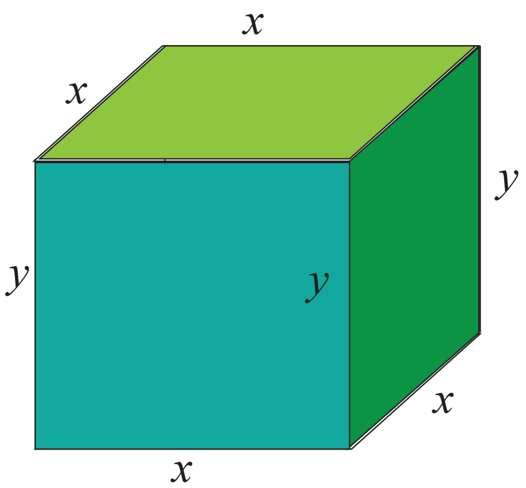

Figure 3: The dimensions of a box.

Deliverables Problem 9

- Complete the function box_cost.

Problem 10: Revenue Prediction

The hotel Pangloss located on a lake has a model for occupancy rate based on the month $m = 0, 1, \ldots, 11$.

Tip: Remember that we work in Python, index start from 0.

$$r(m) \quad = \quad \frac{10}{81}m^3 - \frac{10}{3}m^2 + \frac{200}{9}m + 55 \tag{38}$$

As an example, for January $m = 0$, the occupancy rate is about 55%. For June $m = 5$, the occupancy rate is about 98.21%. The Pangloss has a model for revenue based on occupancy (charging more with higher occupancy):

$$R(r) \quad = \quad (-\frac{3}{5000}r^3 + \frac{9}{50}r^2)1000 \tag{39}$$

For example, for 55% occupancy, the revenue is $R(55) = \$444675.00$. For 98.21% occupancy, the revenue is $R(98.21) = \$1167783.44$. Implement the two functions in Python.

Deliverables Problem 10

- Complete functions r and R.

Student pairs are provided on the next page.

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