

Algorithms and Computational Thinking

Autumn 2018

Tuesday, 2nd October 2018

Boolean Algebra, Variables & Conditional Branching

Exercise 1 : Boolean logic

1. Consider an airplane with three main engines, engine A, B and C. The warning light should switch on if *any* of the following conditions are met :

1. All the three engines A, B and C are down (do not function)
2. Engines A, B are down but C is working
3. Engines A and C are down but B is working
4. Engine A is down but B and C are working

Note that there are two possible states for each engine, i.e., DOWN and WORKING and two possible states for the warning light, ON and OFF. Use boolean variables to request the states of the engines.

Write the truth table representing the functioning of this system and write the boolean expression. (use pen and paper)

Use the following definitions

System : DOWN=0, OK=1

Warning light : OFF=0, ON=1

2. Consider the same scenario as before, but with 4 engines : A, B, C and D. The buzzer should buzz when *any* of the following conditions are met.

1. A and B are down
2. A, C and D are down
3. B, C and D are down
4. B and D are down

As before, write the truth table representing the above system and the boolean expression.

2. Represent the following signed integers (base 10) in their equivalent base 2 (8 bit) representations. (use 2's complement representation coding system for negative numbers)

98, -65, 29, 36, -50, -2, 99, -22

3. The bit operators that we defined can be extended to strings of bits. For instance, the **AND** operator can be defined for two strings of bits (with the same length). The first bit in the result is obtained by applying the **AND** operator to the first bit of the first string and the first bit of the second string. It is a quick and simple operation supported by all processors and used to manipulate values for comparisons and calculations. A bit's position is always counted from the right (least significant) side, advancing left (most significant). For example, the binary value 0001 (decimal 1) has zeroes at every position except at the first one.

Bitwise Not is an operation that calculates the one's complement of the given binary string. Bits that are 0 become 1, and those that are 1 become 0. For example :

```
NOT 0111
=    1000
```

Similarly, a bitwise AND takes two equal-length binary string and performs the logical AND operation on each pair of the corresponding bits, by multiplying them.

```
0101 AND
0011
-----
0001
```

Bitwise operations are performed on binary numbers of equal length. If a number represented in binary does not fill up all the allocated bits, zero's should be padded to the left. For example, the decimal number 5 is represented in 8bit binary format as 00000101.

Using the truth tables shown in the slides (slides number 16 and 17), perform the following boolean operations :

- **NOT T F T T F T F F**
- **NOT F F T F F T**
- **NOT 1 0 0 1 0 0 1 1**
- **F F T F T T F T AND**
 F T F F T F T T
- **T T F F T F F T T F AND**
 T F F T T F F T F F
- **0 1 0 0 0 1 1 0 1 1 AND**
 1 1 0 1 0 0 1 0 1 0
- **F T F T T F T T F F OR**
 F T F F T F T T F T
- **T F T F F F T F T T OR**
 F F T T F T F T F F
- **0 0 1 0 1 1 1 0 1 0 OR**
 0 0 1 1 0 1 1 0 0 1

Exercise 2 : Variables and types

1. Write a Python program to read two positive integers from the user/keyboard and print the sum. Check the output. If you do not get the desired result or get a *TypeError*, check Hint 1 at the end of the document.
2. Assume that in a program you want to swap the values of two variables and b. Write the instructions in Python to do it. For example if $a=2$ and $b=3$, swapping would result in $a=3$ and $b=2$.
3. Write a Python program to intake the radius of the circle ; compute and print the area of the circle. In order to avail precision for π , *import math* in your program and use *math.pi*.
4. Write a Python program to read three arguments representing three sides of a triangle and compute the area of the triangle (hint 3).

Exercise 3 : Conditional branching

1. The 'Nuit du Crime' is taking place at the D! Club in Lausanne. However, the bouncer has some problems calculating the age of the students that want to enter the club. To help him, write a Python program that checks if a student can enter or not (minimum age 18 years) given his/her birth date. Check the type of the user input and perform the required type conversions. Assume that all years have 365 days for simplicity. Sample output.

```
Enter the student birthday:
Year:
>> 1997
Month:
>> 09
Day:
>> 10
Old enough to enter!
```

```
Enter the student birthday:
Year:
>> 2002
Month:
>> 05
Day:
>> 03
Too young!
```

2. Write a Python program to take two inputs from the user, user age (int) and sex (bool), and determine if an individual is able to enter a club. The access rule of the club is to be at least 18 years old for females and at least 20 years old for males.
3. Ask a user to enter a positive integer n greater than 100. Write a Python program that prints the number from 1 to n . But for multiples of three print 'fizz' instead of the number and for the multiples of 5 print 'buzz'. For numbers which are multiples of both three and five print 'fizzbuzz'.

```
Enter a number: 115
1
2
fizz
4
buzz
fizz
7
8
fizz
buzz
11
fizz
13
14
fizzbuzz
16
17
fizz
```

4. Write a python program to convert a positive decimal integer to its binary representation using the long division and count the number of ones present. Print the decimal number, its binary representation and the total number ones.
5. Write a python program to find roots of a second order polynomial ($a.x^2 + b.x + c$) using the discriminant (assume a, b, c are real numbers) (hint 4).

Hint 1 : You can print the type of the variables by using `print(type(variable))`. However, in order to check the variable type in case of conditional branching use, `isinstance(variable, int)`, to check if the variable is an instance of type integer. In python, a *String* is converted to *Integer* using `int(variable)`.

Hint 2 : Python permits swapping through `(a,b) = (b,a)`

Hint 3 : If a, b, c are three sides of a triangle, first compute the semi-perimeter $s = \frac{a+b+c}{2}$, the area of triangle is then $\sqrt{s \times (s - a) \times (s - b) \times (s - c)}$. Use `math.sqrt(x)` to compute the square root of x. The square root can also be computed by using `x**0.5`.

Hint 4 : The discriminant of a quadratic equation, $\Delta = b^2 - 4.a.c$ derived from the coefficients, determine the type of roots. If the discriminant is zero, the equation has two equal real roots. If the discriminant is greater than zero, the equation has two different real roots. If the discriminant is less than zero, the equation has no real roots. The root can then be computed using $x = \frac{-b \pm \sqrt{\Delta}}{2a}$.