CPSC 217,
Loops In Python: Part 2

- Branching vs repetition
- Nesting: branches with loops, loops with branches, loops within loops
- Introducing pseudo code
- The break instruction: how it works and why it should be used sparingly
- Logic errors that may occur with loops: endless loops
- Testing loops

James Tam

Common Mistake #1

- Mixing up branches (`IF` and variations) vs. loops (`while`)
- Related (both employ a Boolean expression) but they are not identical
- Branches
  - General principle: If the Boolean evaluates to true then execute a statement or statements (**once**)
  - Example: display a popup message if the number of typographical errors exceeds a cutoff.
- Loops
  - General principle: As long as (or while) the Boolean evaluates to true then execute a statement or statements (**multiple times**)
  - Example: While there are documents in a folder that the program hasn't printed then continue to open another document and print it.

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Common Mistake #1: Example

- **Program name**: `12branchVsLoop.py`
  - Learning objective: knowing the difference between a branching vs. an iterative (solution).

```
age = int(input("Age positive only: "))
if (age < 0):
    age = int(input("Age positive only: "))
print("Branch:", age)
```

Vs.

```
age = int(input("Age positive only: "))
while (age < 0):
    age = int(input("Age positive only: "))
print("Loop:", age)
```

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Recap: What You Know

- Branching: various forms (e.g. IF, IF-ELSE etc.) along with nested branches.
- Repetition: a single loop runs from start to end.

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Pseudo Code

- A high level solution or algorithm that is not specified in a programming language.
- Instead English-like statements are used.
  - "A high-level description of the actions of a program or algorithm, using a mixture of English and informal programming language syntax" – Python for Everyone (Horstmann, Necaise)
- Benefits: it allows the programmer to focus on the solution without spending a lot time worrying about details such as syntax.

James Tam

Algorithm: Simple Loop, Repeat An Action

- This example (of something you know) will be used to help illustrate how the new concepts work.
- Pseudo code for shoveling the snow for a single residence (single loop)

```
While (sidewalk is not sufficiently shoveled)
   Shovel some snow
```

Optional link to a physical demonstration of the algorithm:
https://www.youtube.com/watch?v=-qDUiIzBuZk

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Nesting

- Recall: **Nested branches** (one inside the other)
  - Nested branches:

```
If (Boolean):
    If (Boolean):
        ...
```

- Branches and loops (`for`, `while`) can be nested within each other

```
# Scenario 1
loop (Boolean):
    if (Boolean):
        ...
```

```
# Scenario 2
    if (Boolean):
        loop (Boolean):
    ...
```

```
# Scenario 3
loop (Boolean):
    loop (Boolean):
        ...
```

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Scenario 1 Algorithm: A Choice (Branch) Each Time A Process Is Repeated (Loop)

- Pseudo code for shoveling the snow for a single residence (single loop)

```
While (sidewalk is not sufficiently shoveled)
   Shovel some snow
   if (very sweaty) then
      wipe brow
   endif
```

Optional link to a physical demonstration of the algorithm:
https://www.youtube.com/watch?v=FtGFszTjBJY

James Tam

Recognizing When Looping & Nesting Is Needed

- **Scenario 1**: As long some condition is met **a question will be asked** (branch = question).
  - Example: As the question is asked if the answer is invalid then an error message will be displayed.
    - **Example**: While the user entered an invalid value for age (too high or too low) then **if the age is too low** an error message will be displayed.
    - Type of nesting: an IF-branch nested inside of a loop

```
loop (Boolean):
    if (Boolean):
        ...
```

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IF Nested Inside A While

- **Program name**: 13nestingIFinsideWHILE.py
  - Learning objective: checking a condition during a repetitive process.

```
age = - 1
MIN_AGE = 1
MAX_AGE = 118
age = int(input("How old are you (1-118): "))
while ((age < MIN_AGE) or (age > MAX_AGE)):
    if (age < MIN_AGE):
        print("Age cannot be lower than", MIN_AGE, "years")
    #(Age for too high also possible (similar)
    age = int(input("How old are you (1-118): "))

print("Age=", age, "is age-okay")
```

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Scenario 2 Algorithm: When Condition Met (Branch) Repeat A Process (Loop)

- Pseudo code for a workday (vs. day off)

```
If (work day)
   while (work there is still work left)
      do some more work
Else
    do non-work stuff
endif
```

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Recognizing When Looping & Nesting Is Needed

- **Scenario 2**: If a question (Boolean expression for a branch) answers true then check if a process should be repeated.
  - **Example**: If the user specified the country of residence as Canada then **repeatedly prompt for the province of residence** as long as the province is not valid.
  - Type of nesting: a loop nested inside of an IF-branch

```
If(Boolean):
    loop():
        ...
```

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While Nested Inside An IF

- **Program name**: 14nestingWHILEinsideIF.py
  - A repetitive process that occurs given a condition has been met

```
country = ""
province = ""
VALID_PROVINCES = "BC, AB, SK, MB, ON, PQ,NL, NB, NS, PEI"
country = input("What is your country of citizenship: ")
if (country == "Canada"):
    province = input("What is your province of citizenship: ")
    while province not in (VALID_PROVINCES):
        print("Valid provinces: %s" %(VALID_PROVINCES))
        province = input("What is your province of citizenship: ")
    print("Country:", country, ", Province:",province)
```

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Scenario 3 Algorithm: Each Time A Repeated Process Begins (1st Outer Loop) Repeat 2nd Process (2nd Inner Loop)

- Pseudo code for shoveling the snow for a multiple residences (nested loop)

```
While (there are some residences to be shoveled)
  While (sidewalk is not sufficiently shoveled)
    Shovel some snow
    if (very sweaty) then
      wipe brow
    endif
```

Optional link to a physical demonstration of the algorithm:
https://www.youtube.com/watch?v=AwlWpSVv864

James Tam

Recognizing When Looping & Nesting Is Needed

- **Scenario 3**: While one process is repeated**, repeat another process**.
  - More specifically: for each step in the first process **repeat the second process from start to end**
  - **Example:** While the user indicates that he/she wants to calculate another tax return prompt the user for income, **while the income is invalid repeatedly prompt for income**.
  - Type of nesting: a loop nested inside of an another loop

```
Loop():
    Loop():
        ...
```

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Nested Loop: Example Process In Pseudo Code

Each time we have a tax return to calculate

```
Do While (user wants to calculate another return)

   Do While (salary invalid)
      Get salary information
   End loop

   Do While (investment income invalid)
      Get investment income
   End loop
End loop
   ...
```

For each client as long as salary invalid repeatedly prompt

Complete each of these steps from start to end

James Tam

While Nested Inside Another While

- **Program name**: 15nestingWHILEinsideWHILE.py
  - Learning objective: a repetitive process that repeats from start to end each time another repetitive process occurs.

```
MIN_INCOME = 0
runAgain = "yes"
while (runAgain == "yes"):
    print("CALCULATING A TAX RETURN")
    income = -1
    while (income < MIN_INCOME):
        income = int(input("Income $"))
    runAgain = input("To calculate another return enter 'yes': ")
```

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Practice Example #2: Nesting

1. Write a program that will count out all the numbers from one to six.
2. For each of the numbers in this sequence the program will determine if the current count (1 – 6) is odd or even.
   a) The program display the value of the current count as well an indication whether it is odd or even.

- Which Step (#1 or #2) should be completed first?

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Step #1 Completed: Now What?

- For each number in the sequence determine if it is odd or even.
- This can be done with the modulo (remainder) operator: %
  - An even number modulo 2 equals zero (2, 4, 6 etc. even divide into 2 and yield a remainder or modulo of zero).
  - `if (counter % 2 == 0): # Even`
  - An odd number modulo 2 does not equal zero (1, 3, 5, etc.)
- Pseudo code visualization of the problem

  Loop to count from 1 to 6

  Determine if number is odd/even and display message

  End Loop
  - Determining whether a number is odd/even is a part of counting through the sequence from 1 – 6, checking odd/even is nested within the loop

James Tam

The Break Instruction

- It is used to terminate the repetition of a loop which is separate from the main Boolean expression (it's another, separate Boolean expression).
- **General structure**:

```
for (Condition 1):
    if (Condition 2):
       break
```

```
while (Condition 1):
    if (Condition 2):
        break
```

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The Break Instruction (2)

- **Program name**: `16break_illustration_only_avoid.py`
  - Learning objective: early termination of a loop occurring any time in the loop body (most for illustration purposes).

```
MIN = 0
MAX = 9
number = random.randrange(MIN,MAX)+1
guess = -1
while (number != guess):
    print("Enter a number from %d-%d: " %(MIN+1,MAX+1), end="")
    guess = int(input())
    if (number == guess):
        print("Guessed correctly")
        break
    elif (guess < number):
        print("Higher.")
    else:
        print("Lower.")
print("Finished the game")
```

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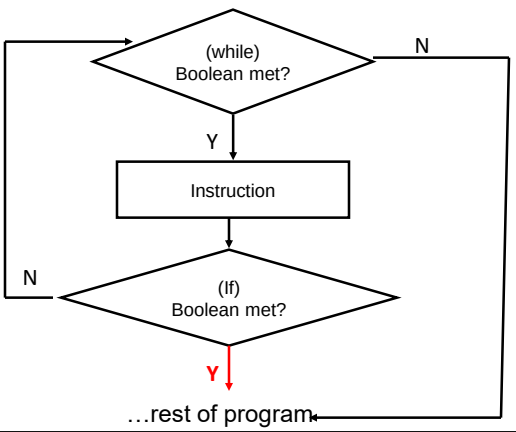
The Break Should Be Rarely Used

- Adding an **extra exit point** in a loop (aside from the Boolean expression in the while loop) may make it harder to trace execution (leads to 'spaghetti' programming).



JT: While adding a single break may not always result in 'spaghetti' it's the beginning of a bad habit that may result in difficult to trace programs

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An Alternate To Using A 'Break'

- **NO:** Instead of an 'if' and 'break' inside the body of the loop

```
while (BE1):
    if (BE2):
        break
```

- **YES**: Add the second Boolean expression as part of the loop's main Boolean expression

```
while ((BE1) and not (BE2)):
```

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Another Alternative To Using A 'Break'

- **YES**: If the multiple Boolean expressions become too complex consider using a 'flag'

```
flag = True
while (flag == True):
    if (BE1):
        flag = False
    if (BE2)
        flag = False
    # Otherwise the flag remains set to true
    # BE = A Boolean expression
```

- Both of these approaches (YES #1 & 2)still provide the advantage of a single exit point from the loop.

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Alternative To Using Break

- **Third, complete and executable example**:
  `17_break_alternative.py`
  - A fully working example for you to look through on your own if you need to see a fully working alternative to using a break.
  - Snippet of the relevant part of the program:

```
while (notDone == True):   #Alternative: while (notDone):
    print("Enter a number from %d-%d: " %(MIN+1,MAX+1),
      end="")
    guess = int(input())
    if (number == guess):
        print("Guessed correctly")
        notDone = False
```

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Infinite Loops

- Infinite loops never end (the stopping condition is never met).
- They can be caused by logical errors:
  - The loop control is never updated (Example 1 – below).
  - The updating of the loop control never brings it closer to the stopping condition (e.g. `i = i - 1` instead of `i = i + 1` in the example below).
- **Program name**: `18infinite_never_updates.py`
- Learning objective: tracing a loop that never ends.

```
i = 1
while (i <= 10):
     print("i = ", i)
i = i + 1
```

```
i =  1
i =  1
i =  1
i =  1
i =  1
i =  1
i =  1
i =  1
i =  1
```

To stop a program with an infinite loop in Unix simultaneously press the <ctrl> and the <c> keys

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Testing Loops

- Make sure that the loop executes the proper number of times.
- Test conditions:
  1) Loop does not run
  2) Loop runs exactly once
  3) Loop runs exactly 'n' times

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Testing Loops: An Example

Program name: `19testing.py`

- Learning objective: minimum tests for a loop that steps through a sequence.

```
sum = 0
i = 1
last = 0

last = int(input("Enter the last number in the sequence to sum : "))
while (i <= last):
    sum = sum + i
    print("i = ", i)
    i = i + 1

print("sum =", sum)
```

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Reminder: Why Is Testing Important?

- Determining “how did on an assignment”
- Because the marking key is posted ahead of time if you test your program thoroughly before submitting the final version then you should get a pretty clear idea of "how you will do".
  - Even if the marking for earlier assignments is not provided before the next assignment comes due you should already have a rough idea of your grade.

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Extra Practice #3

- Write a loop that will continue repeating if the user enters a value that is negative.
- Write a program that will prompt the user for number and an exponent. Using a loop the program will calculate the value of the number raised to the exponent.
  - To keep it simple you can limit the program to non-negative exponents.

James Tam

After This Section You Should Now Know

- How/when to employ nested branches and loops
  - How to trace their execution (branches with loops, loops with branches, loops within loops)
- The `break` instruction, why it should be avoided and alternatives to its use
- What is an infinite loop, some scenarios when they can occur.
- How to test loops (minimum test cases)

James Tam

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