15-110 Principles of Computing – F21

Lecture 9:
While Loops

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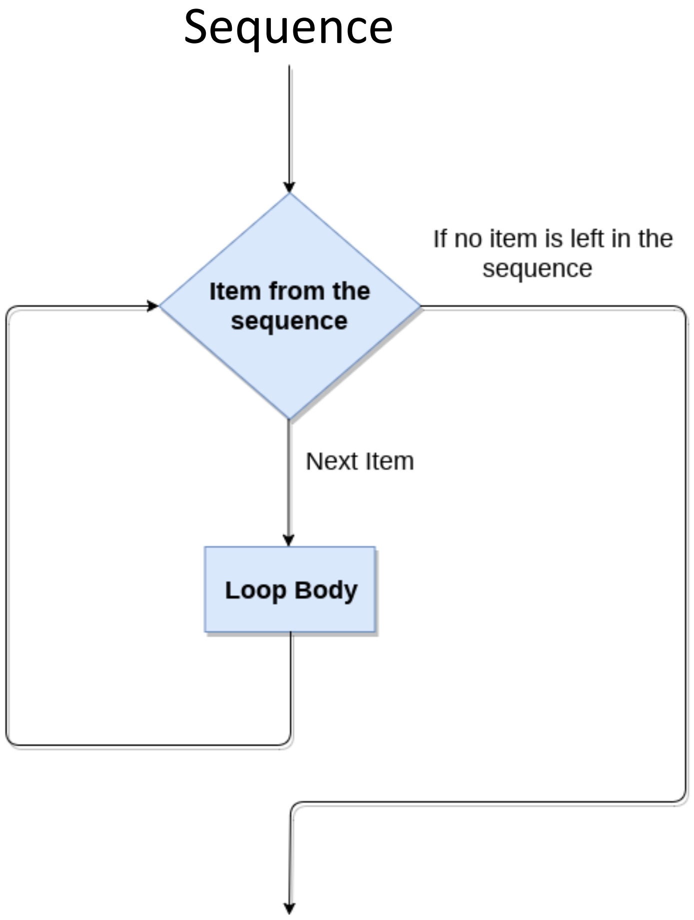
Repeat for a definite number of iterations: `for` construct

- ✓ Repeat a set of actions a **defined number of times** (at *most*)
- ✓ Each time the action *can* be executed on a different input parameter

```
def sum_first(n):
  s = 0
  for i in range(n+1):
     s = s + i
  return s
```

`range(n+1)` → `0, 1, 2, 3, ..., n`

The action `s = s + i` is repeated exactly `n+1` times




```
for i in range(1, 13, 3):
    print(i)
```

How many times the print action will be executed?

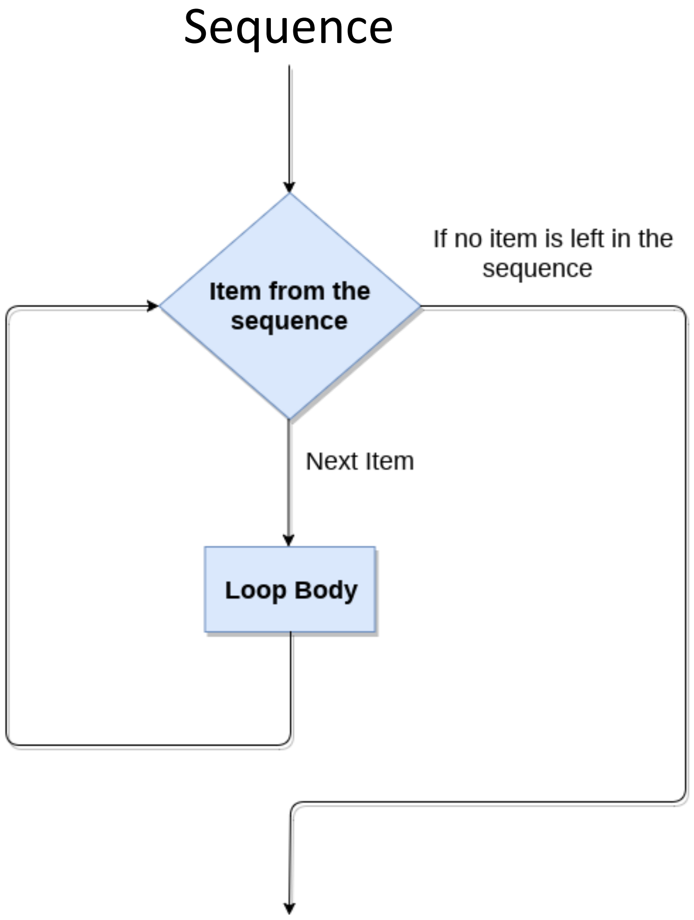
Repeat for a definite number of iterations: `for` construct

```
for i in range(1, 13, 3):
    print(i)
```

How many times the print action will be executed?

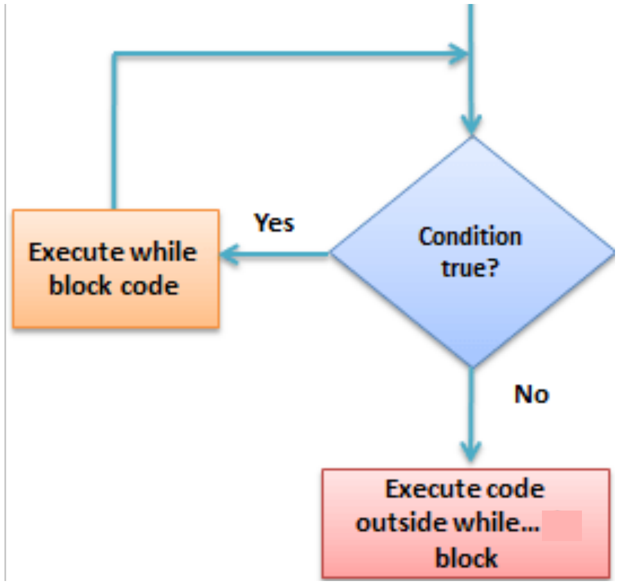
Let's **count** the number of iterations!

```
counter = 0
for i in range(1, 13, 3):
    print(i)
    counter = counter + 1
print('Number of iterations:', counter)
```



Repeat for indefinite (or conditional) iterations: `while` loops

✓ Repeat a set of actions an ***unspecified* number of times:** keep doing as far as a given condition is true




```
while condition_is_true:
    do_something
```

```
def sum_first_10()
    i = 0
    s = 0
    while i <= 10:
        s = s + i
        i = i + 1
    print('Out of while loop!')
    return s
```

vs.

```
def sum_first_10():
  s = 0
  for i in range(n+1):
     s = s + i
  print('Out of while loop!')
  return s
```

✓ `while` loops are more flexible and general than `for` loops, since we are not restricted to iterate over a sequence, but code can be less compact and more prone to errors …

`while` loops unrolled

```python
def sum_first_10():
    i = 0
    s = 0
    while i <= 10:
        s = s + i
        i = i + 1
    print('Out of while loop!')
    return s
```

Equivalent to:

```
1  def sum_first_10():
2      i = 0
3      s = 0
4      if i <= 10:
5          s = s + i
6          i = i + 1
7          go back to line 4
8      else:
9          print('Out of while loop!')
10         return s
```

This is NOT a legal python instruction!
(it's just to explain what happens)

An example: sum up to a maximum value

Implement the function `sumUpToMax(max_value)` that incrementally sums up the integer numbers, starting from 1. It stops when the sum gets higher than `max_value`.

For instance, `sumUpToMax(10)` starts at 1 and adds 2 , 3, 4. It stops there because 1 + 2 + 3 + 4 is 10. In this case, if 5 would be added, the sum would exceed the `max_value` 10.

The function returns the last integer `n` that was used in the sum

```
def sumUpToMax(max_value):
    sum_n = 0
    n = 1
    while sum_n < max_value:
        sum_n = sum_n + n
        n = n + 1
    return n-1
```

Be careful!

- At the exit of the while loop, the variable n has been stepped up one extra time
- What is the value of the variable `sum_n` at the end of the loop? Is it always less than `max_value` or not?

An example: cool the room

Implement the function `decreaseTemperature(t, hot, cooling_step)` that decreases the current room temperature `t` stepwise until it reaches a value below or equal to the `hot` threshold. Each cooling step corresponds to a decrease in temperature of `cooling_step` degrees.

The function returns the new temperature and prints out the number of cooling steps.

```
def decreaseTemperature(t, hot, cooling_step):
    step_num = 0
    while t > hot:
        t = t - cooling_step
        step_num = step_num + 1
    print('Cooling steps: ', step_num)
    return t
```

Never happening loops

✓ Summing up starting from 0

```
n = 1
sum_n = 0
while sum_n < 10:
    sum_n = sum_n + n
    n = n + 1
print('n:', n-1)
```

```
def decreaseTemperature(t, hot, cooling_step):
    step_num = 0
    while t > hot:
        t = t - cooling_step
        step_num = step_num + 1
    print('Cooling steps: ', step_num)
    return t
```

Summing up starting from an arbitrary value

```
decreaseTemperature(22, 28, 2)
```

```
n = 1
sum_n = 10
while sum_n < 10:
    sum_n = sum_n + n
    n = n + 1
print('sum:', sum_n, 'n:', n-1)
```

The body of the loop is never executed!

Never ending loops

```
n = 0
sum_n = 5
while sum_n < 10:
    sum_n = sum_n + n
    n = n - 1
```

Condition `sum_n < 10` is ALWAYS satisfied, the loop will never end

Don't run these codes! → Or run them and then interrupt the kernel (in Consoles)

```
n = 0
sum_n = 0
while True:
    sum_n = sum_n + n
    n = n + 1
```

Condition `True` is ALWAYS satisfied, the loop will never end

Condition `False` is NEVER satisfied, the loop won't start!

```
n = 0
sum_n = 0
while False:
    sum_n = sum_n + n
    n = n + 1
```

Interrupted (infinite) loops: break and return

Make the sum of first n integers until the sum reaches a value greater than 12

Jump out of the loop

```
n = 0
n = 0
sum_n = 0
while True:
    if sum_n + n > 12:
        break
    else:
        sum_n = sum_n + n
        n = n + 1
print('Sum is:', sum_n)
print('n is:', n-1)
```

Equivalent to:

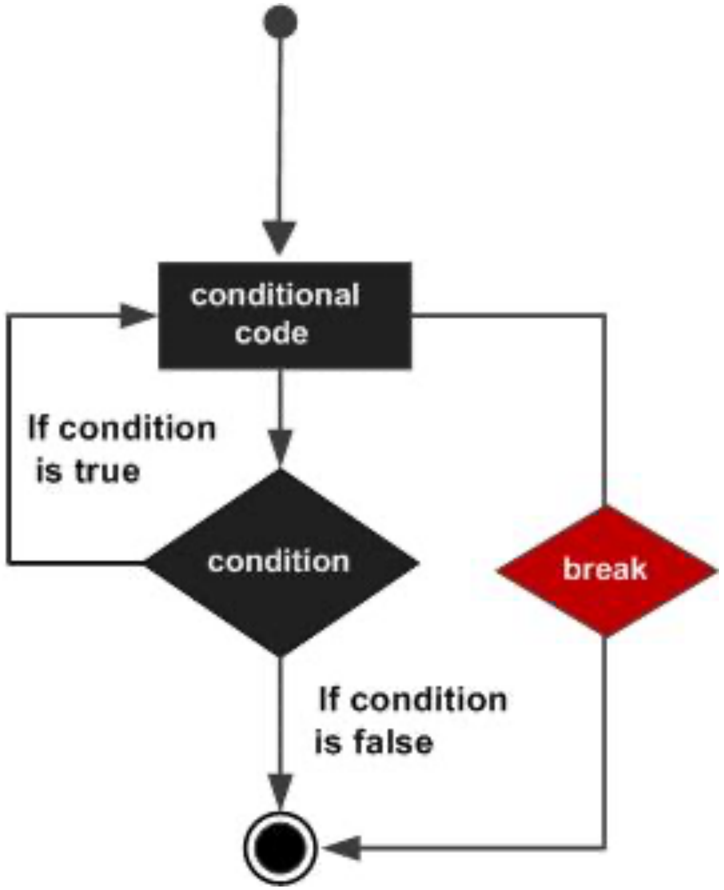
```
n = 0
sum_n = 0
while sum_n <= 12:
    sum_n = sum_n + n
    n = n + 1
print('Sum is:', sum_n - (n-1))
print('n is:', n-2)
```

Interrupted (infinite) loops: break and return

Make the sum of first n integers until the sum reaches a value greater than 12

```
n = 0
n = 0
sum_n = 0
while True:
    if sum_n + n > 12:
        break
    else:
        sum_n = sum_n + n
        n = n + 1
print('Sum is:', sum_n)
print('n is:', n-1)
```

Jump out of the loop



Interrupted (infinite) loops: break and return

- Inside a **function**, `return` exits the loop (and the function!)

```
def sum_return(max_val):
    n = 0
    sum_n = 0
    while True:
        if sum_n + n > 12:
            return sum_n, n-1
        else:
            sum_n = sum_n + n
            n = n + 1
```

Practice: number of digits

Implement the function `numberOfDigits`(n) that returns the number of digits in the input integer `n`

E.g., `numberOfDigits(15110)` should return 5.

```
def numberOfDigits(n):
    d = 0
    while n > 0:
        n = n // 10;
        d = d + 1

    return d
```

```
def numberOfDigits(n):
    p = 0
    while (n % (10 ** p)) != n:
        p = p + 1

    return p
```

Practice: Population increase

You are studying two populations A and B. You know that population A is initially smaller than population B, but it grows at a faster rate. You would like to know haw many days it would take for population A to overtake population B. Luckily you have taken 15-110, and you know it would be faster to sit down and implement a program to compute that for you, than having to do the math each time (you work with a lot of populations of many different organisms...).

Implement the function `populationIncrease(pa, pb, ga, gb)` that takes as parameters:

- The number `pa` of individuals in population A
- The number `pb` of individuals in population B
- The growth rate `ga` of population A (in percent per day)
- The growth rate `gb` of poplation B (in percent per day)

This function should return the number of days it takes for population A to overtake population B.

Important: Populations grow by an integer number of individuals. So if the growth rate is 3.6% and the population is 100, in one day there will be 103 (not 103.6) individuals. If the population is 1000, there will be 1036 individuals.

Practice: Population increase

```python
import math
def populationIncrease(pa, pb, ga, gb):
    return 42

# assert(populationIncrease(100, 150, 1.0, 0) == 51)

# assert(populationIncrease(90000, 120000, 5.5, 3.5) == 16)
# assert(populationIncrease(56700, 72000, 5.2, 3.0) == 12)
# assert(populationIncrease(123, 2000, 3.0, 2.0) == 300)
# assert(populationIncrease(100000, 110000, 1.5, 0.5) == 10)
# assert(populationIncrease(62422, 484317, 3.1, 1.0) == 100)
```

An example

Implement the nearestFactorial(n) function that returns the integer number whose factorial value is the nearest to n while not being greater than n.

For instance, nearestFactorial(25) returns 4. In fact, since $4! = 1\times2\times3\times4 = 24$, while $5! = 1\times2\times3\times4\times5 = 120$, and $24 \leq 25$.

An example: sum up to a maximum value with a start

Implement the function `sumUpToMaxWithStart(start, max_value)` that, starting from the integer value `start`, incrementally sums up the integer numbers. It stops when the sum gets higher than `max_value`.

For instance, `sumUpToMaxWithStart(2, 10)` starts at 2 and adds 3 and 4. It stops there because 2 + 3 + 4 is 9. In this case, if 5 would be added, the sum would exceed the `max_value` 10.

The function returns the last integer used in the sum.
If `start` > `max_value`, 0 is returned.

```
def sumUpToMaxWithStart(start, max_value):
    sum_n = 0
    n = start
    while sum_n < max_value:
        sum_n = sum_n + n
        n = n + 1
    return
```