15-110 Principles of Computing – F21

Lecture 8:
For Loops, Range function

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Repeating actions

Function that returns the sum of the first 10 numbers?

```
def sum_first():
  s = 0
  s = s + 1
  s = s + 2
  s = s + 3
  s = s + 4
  s = s + 5
  s = s + 6
  s = s + 7
  s = s + 8
  s = s + 9
  s = s + 10
  return s
```

```
def sum_first():
  ?
```

Repeating the same action with different inputs for 10 times

`s = s + i`, with `i = 1, 2, ... 10`

Can we summarize this repetitive action in one instruction?

```
def sum_first():
  s = 0
  for i in 1,2,3,4,5,6,7,8,9,10:
     s = s + i
  return s
```

Repeating actions: `for` loops

- General form of a `for` loop construct:

```
for variable in sequence_of_things:
    do_something
```

scope of loop: **indent**!

sequence_of_things: sequence of numbers, characters, strings, ...

variable: *loop index*: at each iteration, **the variable is set to the value of the next item in the sequence**

```
def sum_first():
    s = 0
    for i in 1,2,3,4,5,6,7,8,9,10:
        s = s + i
    return s
```

Repeating actions a definite number of time (at most): `for` loops

```
def sum_first():
  s = 0
  for i in 1,2,3,4,5,6,7,8,9,10:
     s = s + i
  return s
```

- How many times will the instruction(s) in the body of the loop (`s = s + i`) be executed?
  - ➢ **Number of iterations**: 10
  - ✓ The number of iterations is (pre)**defined**
  - ❖ `while` loops for undefined number of iterations

Loop unrolling

```
def sum_first():
  s = 0
  for i in 1,2,3,4,5,6,7,8,9,10:
     s = s + i
  return s
```

Equivalent to:

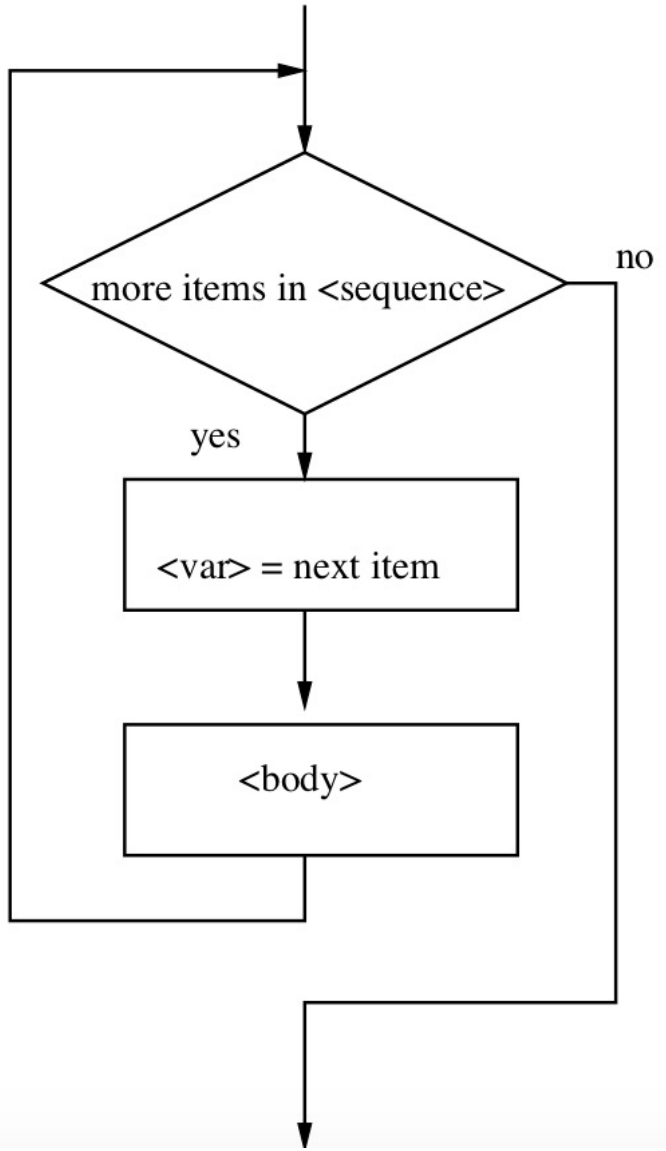
```
def sum_first():
  s = 0
  s = s + 1
  s = s + 2
  s = s + 3
  s = s + 4
  s = s + 5
  s = s + 6
  s = s + 7
  s = s + 8
  s = s + 9
  s = s + 10
  return s
```

Operationally the same as:

```
def sum_first():
  s = 0
  i = 1
  s = s + i
  i = 2
  s = s + i
  i = 3
  s = s + i
  i = 4
  s = s + i
  i = 5
  s = s + i
  i = 6
  s = s + i
  i = 7
  s = s + i
  i = 8
  s = s + i
  i = 9
  s = s + i
  i = 10
  s = s + i
return s
```

Definite loops: `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



Sequences of *things*?

- Can we have sequences of **anything**? → Yes!

```
def print_numbers():
  for i in 1, 2.5, 99.1, -2, 0:
     print(i)
```

```
def print_mix():
  for i in True, 2.5, 99.1, False:
     print(i)
```

- We will learn how to write sequences in different forms

For the time being, we can use sequences as lists of *things* separated by commas

Sequences of integer numbers: `range( )` function

- If we want to repeat something `n` times, where `n` is passed as an input, we need to have a compact way to **automatically generate a sequences of `n` numbers**

```
def sum_first(n):
    ?
```

  - Write a function that prints out *Happy birthday* `n` times, where `n` is a variable input

```
def happy_bday(n):
    for i in range(n):
        print('Happy birthday!')
```

✓ Note that here we are not even using the loop index variable in the body of the for loop, we only need to have a counter for repeating things

Equivalent to:

```
def happy_bday(n):
    for i in 0, 1, 2, ..., n-1:
        print('Happy birthday!')
```

← We can't run this code!!!

Sequences of integer numbers: `range( )` function

- `range(n)` is a function that *returns* a sequence: `0, 1, 2, ..., n-1`

```
def sum_first(n):
    ?
```

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

- ✓ In this case, we are using the loop index variable `i` for the computations in the body of the for loop

Note : `range( )` returns an **object that produces a sequence of integers (a *generator*)**

range(start,end,step)

range(start, end, step) returns an object that produces a sequence of integers from start (inclusive) to end (exclusive) by step.

```
s = 0
for i in range(1, 10, 2):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(-2, 10, 2):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(0, 10, 5):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(-5, 11, 5):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

Short forms: `range(end)`, start from 0, steps of 1

`range(end)` returns an object that produces a sequence of integers
from 0 to end (exclusive) by steps of 1

```
s = 0
for i in range(5):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(0, 5, 1):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(10):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

Short forms: `range(start,end)`, steps of 1

`range(start, end)` returns an object that produces a sequence of integers
from start (inclusive) to end (exclusive) by steps of 1

```
s = 0
for i in range(10, 15):
      print('Loop variable:', i)
      s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(-10, 1):
      print('Loop variable:', i)
      s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(10, 15, 1):
      print('Loop variable:', i)
      s = s + i
print('Sum:', s)
```

range(start, end, back_steps), start > end

If `start > end`, step must be **negative**! (stepping backward)

```
s = 0
for i in range(10, 5, -1):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(20, 12, -2):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(0, -5, -1):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

```
s = 0
for i in range(10, 5):
    print('Loop variable:', i)
    s = s + i
print('Sum:', s)
```

For loops for summing up

Write the function `sum_all (r_min, r_max)` that sums up all the integer numbers between the integer values `r_min` and `r_max` (included).

```
def sum_all(r_min, r_max):
    s = 0
    for i in range(r_min, r_max+1):
        s = s + i
    return s
```

For loops for summing up the odds numbers

Write the function `sum_odds(r_min, r_max)` that sums up all the integer odd numbers between the integer values `r_min` and `r_max` (included).

```
def sum_odds(r_min, r_max):
    s = 0
    for i in range(r_min, r_max+1):
        if i % 2 != 0:
            s = s + i
    return s
```

Is this code optimized?

If we know that `r_min` is an odd number:

```
def sum_odds(r_min, r_max):
    s = 0
    for i in range(r_min, r_max+1, 2):
        s = s + i
    return s
```

What if we don't know whether `r_min` is an odd number or not?

Watch out: the loop index variable

```
a = 3
b = 10
s = 0
for i in range(a, b, 2):
    s = s + i
print(s)
print(i) ?????
```

```
a = 3
b = 10
s = 0
for i in range(a, b+1, 2):
    s = s + i
print(s)
print(i)
```

- **Loop index variable**:
  - ✓ The variable created for the for loop doesn't disappear after the loop is done
  - ✓ It will contain the last value used in the `for` loop

```
a = 3
b = 10
s = 0
for i in range(a, b+2, 2):
    s = s + i
print(s)
print(i)
```

Watch out: the loop index variable

```
a = 3
b = 10
s = 0
for i in range(a, b, 2):
    s = s + i
    i = 2 * i

print(s)
print(i) ?????
```

- **Loop index variable**:
  - ✓ It *can* be changed inside the loop
  - ✓ Don't do it!

For loops for summing up: Alternating sum

The **alternating sum** of a sequence of numbers $a_1, a_2, a_3, a_4.., a_n$ is defined as: $a_1 - a_2 + a_3 - a_4 + .. \pm a_n$

Write the function `alternatingSum(n)` that returns the alternating sum of all integer numbers between 1 and `n`, inclusive.

```
def alternatingSum(n):

    s_pos = 0
    for i in range(2, n+1, 2):
        s_pos = s_pos + i

    s_neg = 0
    for j in range(1, n+1, 2):
        s_neg = s_neg + j

    return s_pos - s_neg
```

```
def alternatingSum(n):
    s = 0
    for i in range(1, n+1):
        if i % 2 == 0:
            s = s + i
        else:
            s = s - i
    return s
```

(wrong! These codes are computing: $-a_1 + a_2 - a_3 + a_4 + .. \pm a_n$)

For loops for summing up after selection

Write the function `sum_if_divisible(a, b)` that returns the sum of all the integer numbers between the integer values `a` and `b` (included) that can be divided by 2 or by 3, or by both (e.g., 9 can be divided by 3, 6 can be divided by both, 5 can't be divided neither by 2 or by 3).

```
def sum_if_divisible(a, b):
    s = 0
    for v in range(a, b+1):
        if (v % 2 == 0) or (v % 3 == 0):
            s = s + v
    return s
```

For loops for summing up: Fibonacci's sequence

❖ The **Fibonacci Sequence** is the series of numbers: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, ...

➢ The next number in the sequence is found by adding up the two numbers before it:

- $a_3 = 1 \leftarrow (0+1)$
- $a_4 = 2 \leftarrow (1+1)$
- $a_5 = 3 \leftarrow (1+2)$
- ...
- $a_i = a_{i-1} + a_{i-2}$

✓ The first two numbers, a_1, a_2 are given: different two initial numbers generate different sequences

Write the function `Fibonacci(a1, a2, n)` that computes and prints out all the integer numbers in the sequence up to sequence index `n` (included) based on the first two numbers in the sequence, `a1`, `a2`.

For loops for the perfect numbers

In mathematics, a **perfect number** is an integer for which the sum of all its own positive divisors (excluding itself) is equal to the number itself. For example, the number 6 is perfect, because 1+2+3 is equal to 6. Other perfect numbers are 28, 496, and 8,128.

Implement the function `isPerfect(n)` that returns `True` if `n` is a perfect number, or `False` otherwise.

```
def isPerfect(n):
    s = 0
    for i in range(1, n):
        if n % i == 0:
            s = s + i
    if s == n:
        return True
    else:
        return False
```

For loops for summing up, a bit more general scenario

Write the function `sum_odds_general(r_min, r_max)` that sums up all the integer odd numbers between the values `r_min` and `r_max` (included).
`r_min` and `r_max` can be any numbers and aren't necessarily integers but `r_min` $\leq$ `r_max`

```
import math

def sum_odds_general(r_min, r_max):
    s = 0
    r_min = math.floor(r_min)
    r_max = math.ceil(r_max)
    print(r_min, r_max)

    if r_min % 2 == 0:
        start = r_min + 1
    else:
        start = r_min

    for i in range(start, r_max+1, 2):
        s = s + i
    return s
```