http://www.cs.cornell.edu/courses/cs1110/2020sp

Lecture 23: **while Loops**

(Sections 7.3, 7.4)

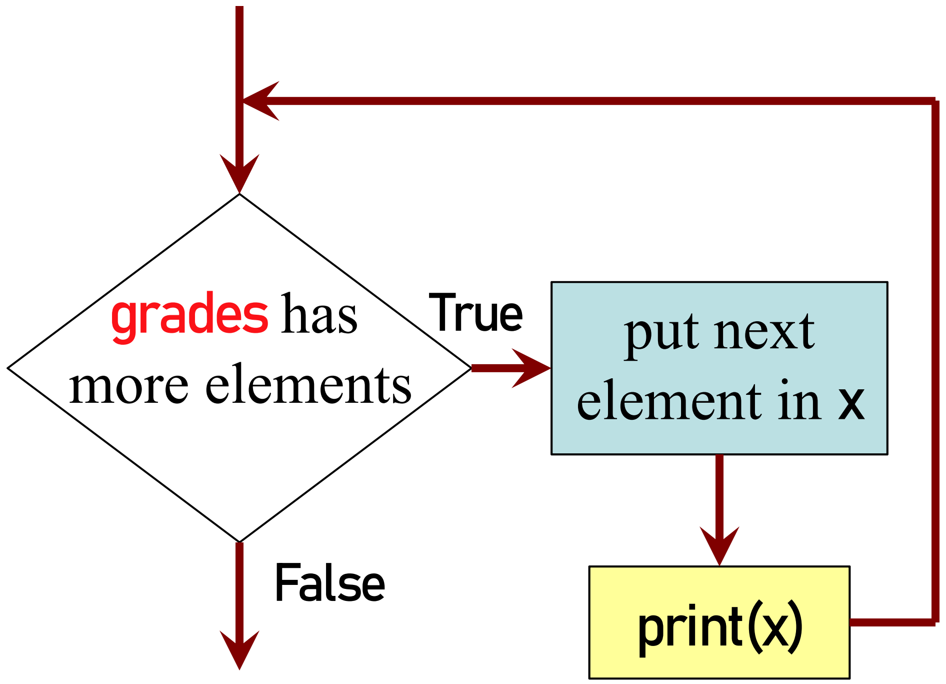
CS 1110

Introduction to Computing Using Python

[E. Andersen, A. Bracy, D. Fan, D. Gries, L. Lee,
S. Marschner, C. Van Loan, W. White]

Recall: For Loops

```
for x in grades:
    print(x)
```



- **loop sequence:** grades
- **loop variable**: x
- **body**: print(x)

To execute the for-loop:

1. Check if there is a "next" element of **loop sequence**
2. If so:
   - *assign* next sequence element to **loop variable**
   - Execute all of **the body**
   - Go back to Line 1
3. If not, terminate execution

Different types of Repetition

1. Process each item in a sequence
    - Compute statistics for a dataset
    - Send all your contacts an email

```
for x in sequence:
    process x
```

2. Do something *n* times
    - Draw a checkers board
    - Run a protein-folding simulation for 10^6 time steps

```
for x in range(n):
    do something
```

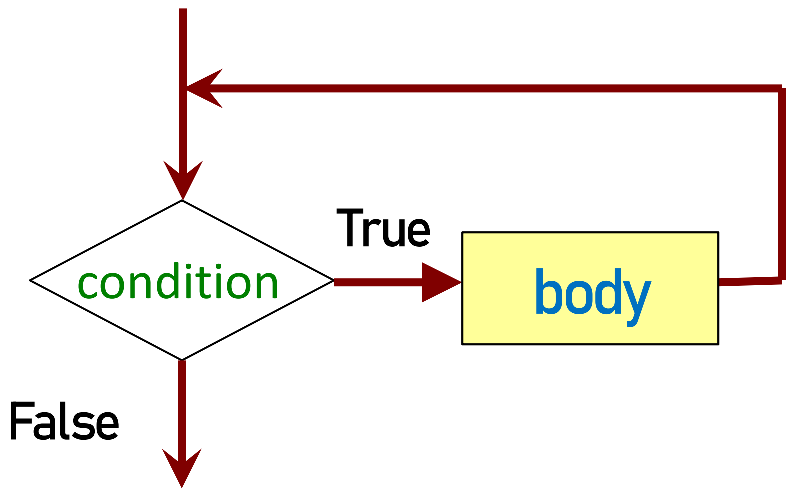
3. Do something an unknown number of times
    - Play word guessing game until 6 strikes
    - Go in current direction until edge is detected

```
???
```

https://www.flickr.com/photos/janitors/albums/72157642146435575/with/13058966193/

Beyond Sequences: The while-loop

```
while <condition>:
    statement 1  ⎫
    …            ⎬ body
    statement n  ⎭
```



- Relationship to **for-loop**
  - Broader notion of "keep working until done"
  - Must explicitly ensure condition becomes false
  - *You* explicitly manage what changes per iteration

While-Loops and Flow

```
import random

num = random.randint(0,10)
guessed_it = False
print("I'm thinking of a number.")

while not guessed_it:
    guess = int(input('Guess it: '))
    guessed_it = (num == guess)
print('Well done!')
```

```
I'm thinking of a number.
Guess it: 6
Guess it: 2
Guess it: 1
Guess it: 4
Well done!
```

Continuation condition, not stopping condition

Q1: What gets printed?

```
a = 0
while a < 1:
    a = a + 1


print(a)
```

```
a = 0
while a < 2:
    a = a + 1


print(a)
```

```
a = 0
while a > 2:
    a = a + 1


print(a)
```

Q2: What gets printed?

```
a = 4
while a > 0:
    a = a - 1


print(a)
```

```
a = 0
while a < 3:
   if a < 2:
       a = a + 1


print(a)
```

Q3: What gets printed?

```
a = 8
b = 12
while a != b:
    if a > b:
        a = a - b
    else:
        b = b - a
print(a)
```

A: *Infinite loop*
B: 8
C: 12
D: 4
E: *I don't know*

This is Euclid's Algorithm for finding the greatest common factor of two positive integers.
Trivia: It is one of the *oldest* recorded algorithms (~300 B.C.)

Start next video:

`while` **or** `for` ?

for vs. while

- You can almost always use either

Called "definite iteration"

- Sometimes for is better
  - Do something a fixed (pre-determined) number of times
- Sometimes while is better
  - Do something an indefinite (not infinite) number of times
  - E.g., do something until some event happens, i.e., until a stopping condition is reached

Called "indefinite iteration"

for vs. while

do something n times

```
for k in range(n):
    # do something
```

```
k = 0
while k < n:
    # do something
    k = k+1
```

Must remember to increment

My preference? for-loop

for vs. while

do something an unknown number of times

```
                 ??
for k in range(BIG_NUM):
      # do something
      if time to stop:
          break
```

```
while not time to stop:
    # do something
```

Do NOT use break in any work you submit in CS1110.
Practice using while-loop in situations where while-loop is well suited

My preference? while-loop

for vs. while

do something to each element of a sequence

```
for k in range(len(seq)):
    seq[k] = seq[k]+1
```

```
k = 0
while k < len(seq):
    seq[k] = seq[k]+1
    k = k+1
```

while is more flexible, but sometimes requires more code

My preference? for-loop

for vs. while

do something until a limit is reached
e.g., make a table of squares up to N

```
seq = [ ]
sqn= math.floor(sqrt(N))
for k in range(sqn+1):
    seq.append(k*k)
```

```
seq = [ ]
k = 0
while k*k < N:
    seq.append(k*k)
    k = k+1
```

for-loop requires you to know how many iterations you want **ahead of time**

can use complex expressions to check if a task is done

My preference? while-loop

for vs. while

change a sequence's length

e.g., remove all 3's for list nums

```
for i in range(len(nums)):
    if nums[i] == 3:
        del nums[i]
```

IndexError: list index out of range

```
while 3 in nums:
    nums.remove(3)
```

is this not beautiful?

My preference? while-loop

for vs. while

Fibonacci numbers:

$$F_0 = 1$$
$$F_1 = 1$$
$$F_n = F_{n-1} + F_{n-2}$$

find 1st n Fibonacci numbers

```
fib = [1, 1]
for k in range(2,n):
    fib.append(fib[-1] + fib[-2])
```

Last item in list

Second-last item in list

loop variable not always **used**

```
fib = [1, 1]
while len(fib) < n:
    fib.append(fib[-1] + fib[-2])
```

loop variable not always **needed** at all

My preference? while-loop

Using while-loops Instead of for-loops

Advantages

- Better for **modifying data**
  - More natural than range
  - Works better with deletion
- Better for **convergent tasks**
  - Loop until calculation done
  - Exact steps are unknown
- Easier to **stop early**
  - Just set loop var (keep_going) to False

Disadvantages

- **Infinite loops** more likely
  - Easy to forget loop vars
  - Or get continuation condition wrong
- **Require** more management
  - Initialize the condition?
  - Update the condition?

Start next video:

How to set up a while loop

Setting up a while-loop

0. Situation is to do something until an event happens
1. Write the continuation condition
   - Create var names as necessary to express condition
   - May be easier to negate stop condition to get continuation condition
2. Initialize loop vars (vars in loop condition) as necessary
3. In loop body: update loop vars

   to possibly change loop condition from True to False
4. Write the rest of the loop body

Improve number guessing game

```
import random
min_num= 1
max_mum= 10
max_chances= 5
secret_num= random.randint(min_num, max_mum)
print("I have a number from "+str(min_num)+" to "+str(max_mum))
print("You have "+str(max_chances)+" chances to guess it")

# User guesses until all chances used up or guessed correctly
```

1. Allow fixed number of guesses

For you to add later:

2. If a guess is wrong, tell player whether it was too high or too low.