CS 1110:
Introduction to Computing Using Python

Lecture 20

isinstance and While Loops

[Andersen, Gries, Lee, Marschner, Van Loan, White]

Announcements

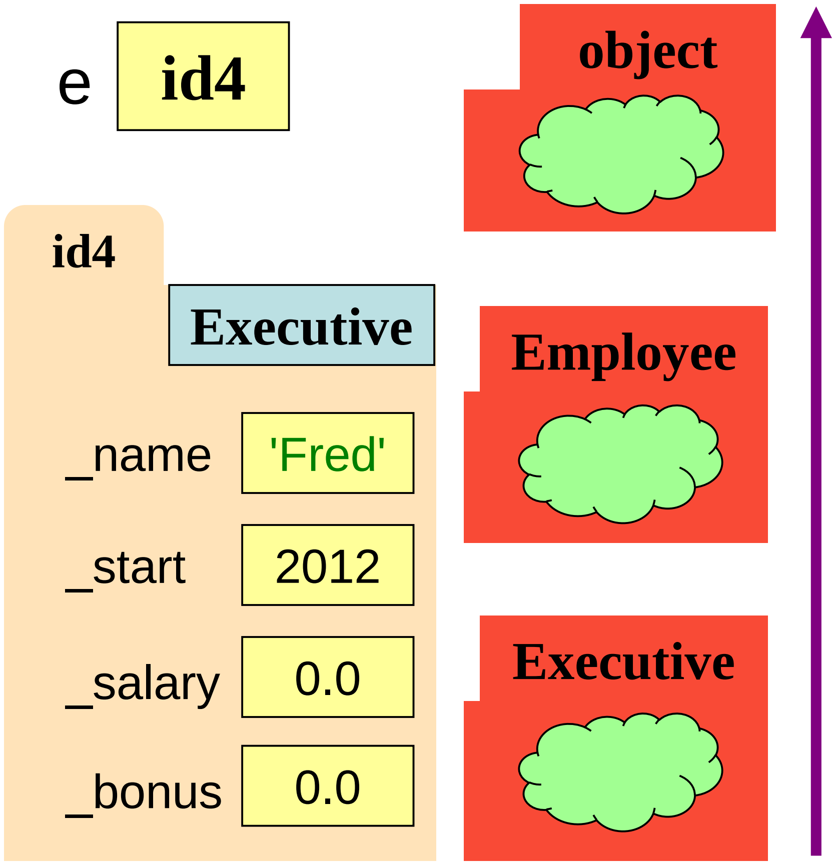
- A4: Due 4/20 at 11:59pm
  - Should only use our str method to test __init__
  - Testing of all other methods should be done as usual
- Thursday 4/20: Review session in lecture
- Prelim 2 on Tuesday 4/25, 7:30pm – 9pm
  - Covers material up through Tuesday 4/18
  - Lecture: Professor office hours
  - Labs: TA/consultant office hours
- No labs on 4/26

More Mixed Number Example

- What if we want to add mixed numbers and fractions?

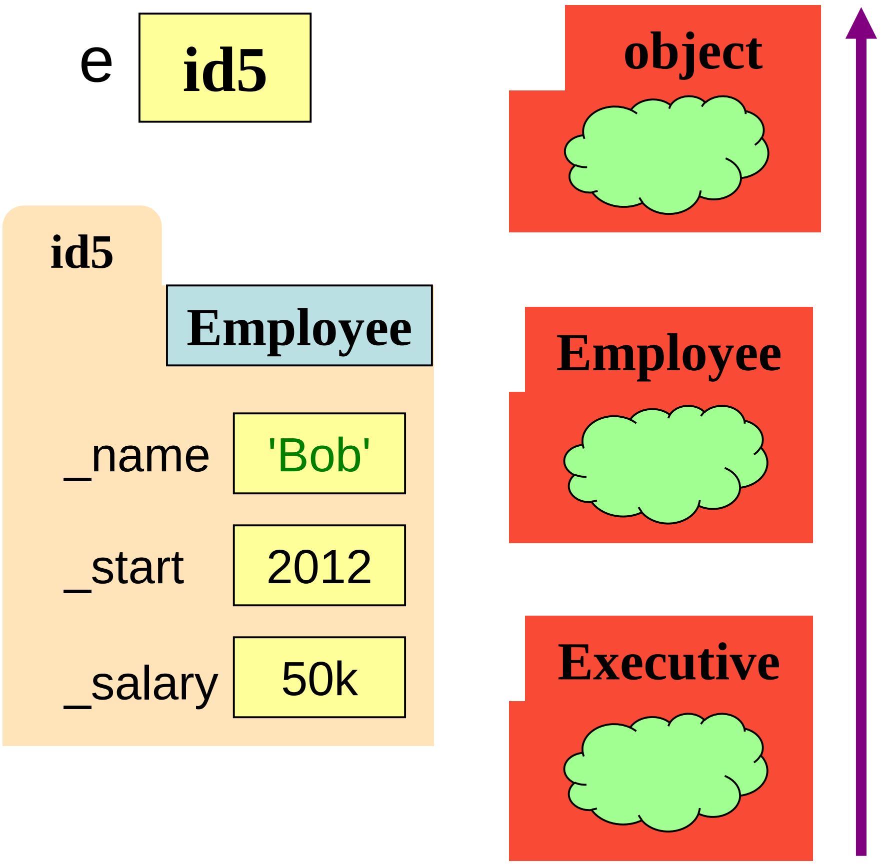
The isinstance Function

- isinstance(<obj>,<class>)
  - True if <obj>'s class is same as or a subclass of <class>
  - False otherwise
- **Example**:
  - isinstance(e,Executive) is True
  - isinstance(e,Employee) is True
  - isinstance(e,object) is True
  - isinstance(e,str) is False
- Generally preferable to type
  - Works with base types too!



isinstance and Subclasses

```
>>> e = Employee('Bob',2011)
>>> isinstance(e,Executive)
???
```



FALSE

More Mixed Number Example

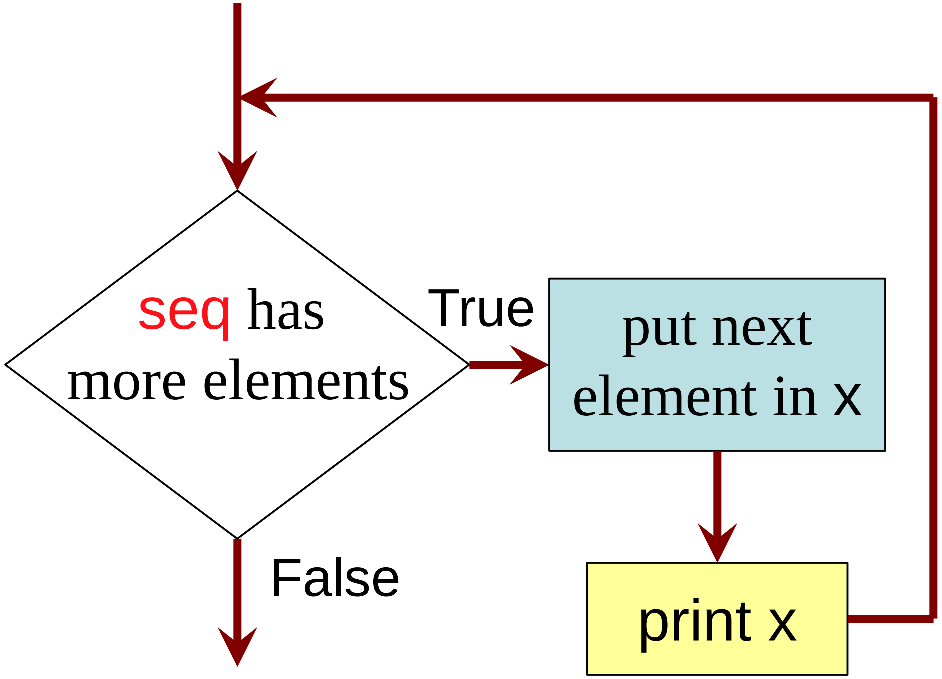
- What if we want to add mixed numbers and fractions?

Review: For Loops

The for-loop:

```
for x in seq:
    print x
```

- **loop sequence:** seq
- **loop variable**: x
- **body**: print x



To execute the for-loop:

1. Check if there is a "next" element of **loop sequence**
2. If not, terminate execution
3. Otherwise, *assign* element to the **loop variable**
4. Execute all of **the body**
5. Repeat as long as 1 is true

Beyond Sequences: The while-loop

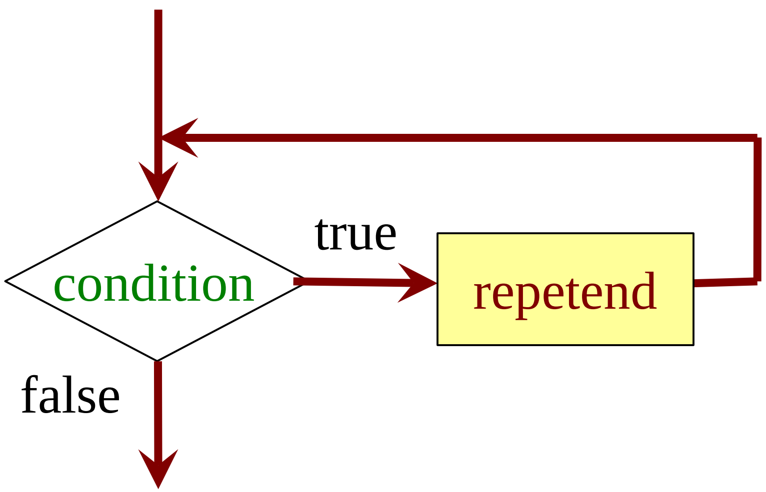
while <*condition*>:

statement 1

...

statement n

repetend or **body**



- Relationship to for-loop
  - Must explicitly ensure condition becomes false
  - *You* explicitly manage what changes per iteration

While-Loops and Flow

```
print 'Before while'
count = 0
i = 0
while i < 3:
    print 'Start loop '+str(i)
    count = count + i
    i = i + 1
    print 'End loop '
print 'After while'
```

Output:

```
Before while
Start loop 0
End loop
Start loop 1
End loop
Start loop 2
End loop
After while
```

What gets printed?

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

print a
```

prints 1

What gets printed?

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


print a
```

prints 2

What gets printed?

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


print a
```

prints 0

What gets printed?

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

print a
```

INFINITE LOOP

What gets printed?

```
a = 4
while a > 0:
    a = a – 1


print a
```

prints 0

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 **CORRECT**

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.)

More Mixed Number Example

- Adding with greatest common factor, finally!
- Reducing

Note on Ranges

- m..n is a range containing n+1-m values
  - 2..5 contains 2, 3, 4, 5. Contains 5+1 – 2 = 4 values
  - 2..4 contains 2, 3, 4. Contains 4+1 – 2 = 3 values
  - 2..3 contains 2, 3. Contains 3+1 – 2 = 2 values
  - 2..2 contains 2. Contains 2+1 – 2 = 1 values
- Notation m..n always implies that m <= n+1
  - If m = n+1, the range has 0 values

while Versus for

```
# process range b..c-1
for k in range(b,c)
    # code involving k
```

```
# process range b..c-1
k = b
while k < c:
    # code involving k
    k = k+1
```

Must remember to increment

```
# process range b..c
for k in range(b,c+1)
    # code involving k
```

```
# process range b..c
k = b
while k <= c:
    # code involving k
    k = k+1
```

while Versus for

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

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

while is more flexible, but often requires more code

Patterns for Processing Integers

range a..b-1

```
i = a
while i < b:
    # process integer i
    i = i + 1
```

```
# store in count # of '/'s in string s
count = 0
i = 0
while i < len(s):
    if s[i] == '/':
        count = count + 1
    i = i +1
# count is # of '/'s in s[0..s.length()-1]
```

range c..d

```
i = c
while i <= d:
    # process integer i
    i = i + 1
```

```
# Store in v the sum 1/1 + 1/2 +
    …+ 1/n
v = 0
i = 0
while i <= n:
    v = v + 1.0 / i
    i = i +1
# v= 1/1   + 1/2 + …+ 1/n
```

while Versus for

```
# list of squares to N
seq = []
n = floor(sqrt(N)) + 1
for k in range(n):
    seq.append(k*k)
```

```
# list of squares to N
seq = []
k = 0
while k*k <= N:
    seq.append(k*k)
    k = k+1
```

A for-loop requires that you know where to stop the loop **ahead of time**

A while loop can use complex expressions to check if the loop is done

while Versus for

Fibonacci numbers:

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

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

gets last element

gets second-to-last element

Sometimes you do not use the loop variable at all

```
# List of n Fibonacci numbers
fib = [1, 1]
while len(fib) < n:
    fib.append(fib[-1] + fib[-2])
```

Do not need to have a loop variable if you don't need one

Cases to Use while

Great for when you must **modify** the loop variable

```
# Remove all 3's from list t
i = 0
while i < len(t):
    # no 3's in t[0..i–1]
    if t[i] == 3:
        del t[i]
    else:
        i += 1
```

```
# Remove all 3's from list t
while 3 in t:
    t.remove(3)
```

Cases to Use while

Great for when you must **modify** the loop variable

But first, +=

- Can shorten `i = i + 1` as:
  - `i += 1`
- Also works for `-=`, `*=`, `/=`, `%=`

Cases to Use while

Great for when you must **modify** the loop variable

```
# Remove all 3's from list t
i = 0
while i < len(t):
    # no 3’s in t[0..i–1]
    if t[i] == 3:
        del t[i]
    else:
        i += 1
```

Stopping point keeps changing.

```
# Remove all 3's from list t
while 3 in t:
    t.remove(3)
```

The stopping condition is not a numerical counter this time. Simplifies code a lot.

Collatz Conjecture

- Does this loop terminate for all x?

```
while x != 1:
    if x % 2 == 0:     # if x is even
        x /= 2
    else:              # if x is odd
        x = 3 * x + 1
```

WHILE LOOPS CAN BE HARD. Must think formally.

Some Important Terminology

- **assertion**: true-false statement placed in a program to *assert* that it is true at that point
  - Can either be a **comment**, or an **assert** command
- **invariant**: assertion supposed to "always" be true
  - If temporarily invalidated, must make it true again
  - **Example**: class invariants and class methods
- **loop invariant**: assertion supposed to be true before and after each iteration of the loop
- **iteration of a loop**: one execution of its body

Preconditions & Postconditions

precondition

```
# x  = sum of 1..n-1
x = x + n
n = n + 1
# x =  sum of 1..n-1
```

postcondition

n

1 2 3 4 5 6 7 8

x contains the sum of these (6)

n

1 2 3 4 5 6 7 8

x contains the sum of these (10)

- **Precondition:** assertion placed before a segment
- **Postcondition:** assertion placed after a segment

Relationship Between Two

If precondition is true, then postcondition will be true