# CS 1110

## Lecture 19: While loops

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Announcements

**Prelim 2 conflicts info due on CMS by midnight tonight.**

S/U students do *not* take prelim 2.

**A4 released; note suggested milestone deadlines**

**Reading for next time (important, and requires concentration)**

http://www.cs.cornell.edu/Courses/cs1110/2013sp/materials/loop_invariants.pdf

Slides by D. Gries, L. Lee, S. Marschner, W. White

# Iteration: Doing things repeatedly

1. Process each item in a sequence
   - Compute aggregate statistics for a dataset, such as the mean, standard deviation, etc.
   - Send everyone in a social-media group an appointment time

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

2. Perform *n* trials or get *n* samples
   - Draw *n* cards to make a poker hand
   - Run a protein-folding simulation for $10^6$ time steps

```
for x in range(n):
    do next thing
```

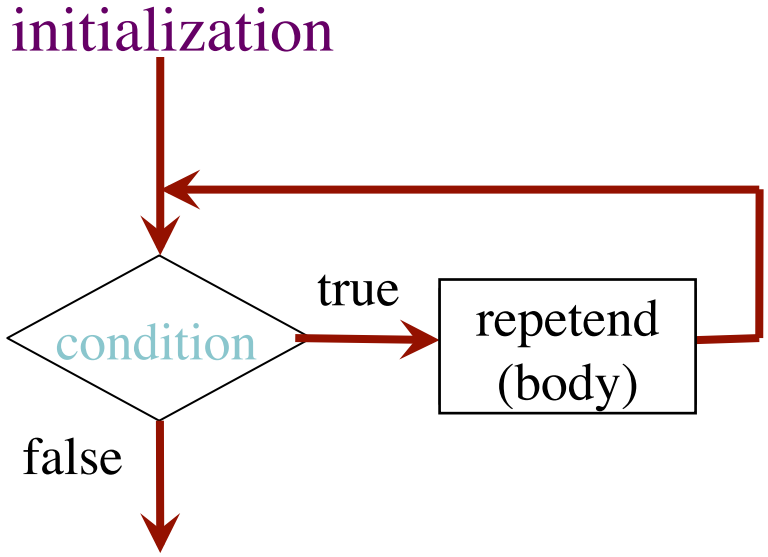
3. Do something an unknown number of times
   - CUAUV team, vehicle keeps moving until reached its goal

????

Richard King

# Beyond Iteration on Iterables: The while-loop

```
<initialization>
while <condition>:
    statement 1
    ...
    <stmt(s) that could
      invalidate condition>
    ...
    statement n
```




**Four "loopy" questions for reasoning about correctness:**

1. How does it start?
2. When is there still work to do? (what's the opposite of done?)
3. How do we make progress?
4. How do we make sure the loop body does the right thing?

# While-Loops and Flow

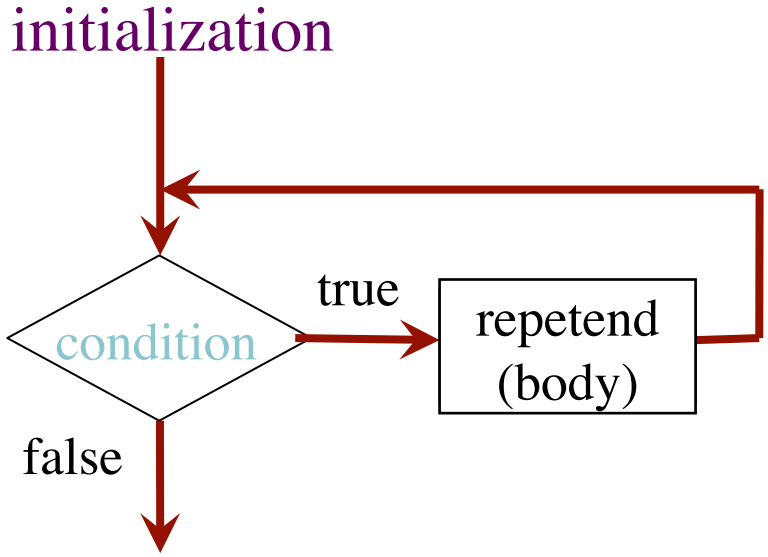
```
1. print 'Before while'
2. i = 0
3. while i < 3:
4.     print 'Start loop i', i
5.     i += 1
6.     print 'End loop'
7. print 'After while'
```

Output:

```
Before while [from line 1]
Start loop i 0 [from 4]
End loop [from 6]
Start loop i 1[from 4]
End loop [from 6]
Start loop i 2 [from 4]
End loop [from 6]
After while [from 7]
```

# Beyond Iteration on Iterables: The while-loop

```
<initialization>
while <condition>:
    statement 1
    ...
    <stmt(s) that could
      invalidate condition>
    ...
    statement n
```




**Four "loopy" questions for reasoning about correctness:**

1. How does it start?
2. When is there still work to do? (what's the opposite of done?)
3. **How do we make progress? (the "*increment*")**
4. How do we make sure the loop body does the right thing?

# while Versus for

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

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

For-loops handle "book-keeping" implicitly in the execution's position in the for-statement list.

While-loops aren't inherently based on lists.

# Case: book-keeping more natural w/out list

```
print "\nHope you had a happy Valentine's Day!"
raw_input("Press 'return' to pick a flower. ")
f = Flower()
print "New flower picked. "

while f.num_petals > 0:
    raw_input('Press "return" to pluck a petal. ')
    pluck(f)
```

# Case: easier to phrase stopping condition

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

```
# store squares up 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

# Case: no list-based expression of stopping

```
def sqrt(c):
    """Return: square root of c
    Uses Newton's method
    Pre: c >= 0 (int or float)"""
    x = c/2.0
    # Check for convergence
    while abs(x*x - c) > 1e-6:
        # Get x_{n+1} from x_n
        x = x / 2 + c / (2*x)

    return x
```

- Want square root of $c$
  - Make poly $f(x) = x^2 - c$
  - Want root of the poly ($x$ such that $f(x)$ is 0)
- Use **Newton's Method**
  - $x_0$ = GUESS ($c/2$??)
  - $x_{n+1} = x_n - f(x_n)/f'(x_n)$
    $= x_n - (x_n x_n - c)/(2x_n)$
    $= x_n - x_n/2 + c/2x_n$
    $= x_n/2 + c/2x_n$
  - Stop when $x_n$ good enough

You'll see a (simple) termination like this in A4.

# Case: modification of sequence desired

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

```
# Replace all 5's in list t with 4's
while 5 in t:
    i5 = t.index[5]
    t[i5] = 4
```

# Note on Ranges

- m..n is a range containing n+1-m ints: m, m+1, ..., n
  ("followers minus first")
  - 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
  - 2..1 contains ???
- The notation m..n always implies that m <= n+1
  - So you can assume this even if we do not say it
  - If m = n+1, the range has 0 values

# Note on Ranges

- m..n is a range containing the n+1-m values m, m+1, ... n
  - 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

What does 2..1 contain?

A: nothing
B: 2,1
C: 1
D: 2
E: something else

# Patterns for Processing Integers

## range a..b-1

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

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

## range c..d

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

```
# Store in v the sum: 1.0/k for k in 1..n
# 1/1   + 1/2 + ...+ 1/n
v = 0
i = 1 # v is sum of 1.0/k for k in 1..i-1
while i <= n:
    v = v + 1.0 / i
    i += 1
# v= 1/1   + 1/2 + ...+ 1/n
```