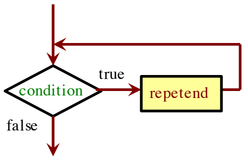
Beyond Sequences: The while-loop

```
while <condition>:
    statement 1
    ...
    statement n
```

repetend or body



- Relationship to for-loop
  - Broader notion of "still stuff to do"
  - 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
```

while Versus for

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

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

Must remember to increment

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

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

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
  - 2..1 contains ???
- The notation m..n, always implies that m <= n+1
  - So you can assume that even if we do not say it
  - If m = n+1, the range has 0 values

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 double var. v the sum
# 1/1  + 1/2 + ...+ 1/n
v = 0;    # call this 1/0 for today
i = 0
while i <= n:
    v = v + 1.0 / i
    i= i +1
# v= 1/1  + 1/2 + ...+ 1/n
```

while Versus for

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

```
# table 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:
$F_0 = 1$
$F_1 = 1$
$F_n = F_{n-1} + F_{n-2}$

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

Sometimes you do not use the loop variable at all

```
# Table of n Fibonacci nums
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
```

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.

Cases to Use while

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

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

Recall Lab 9

```
Welcome to CS 1110 Blackjack.
Rules: Face cards are 10 points. Aces are 11 points.
    All other cards are at face value.

Your hand:
2 of Spades
10 of Clubs

Dealer's hand:
5 of Clubs

Type h for new card, s to stop:
```

How do we design a complex while-loop like this one?

Play until player **stops** or **busts**

Some Important Terminology

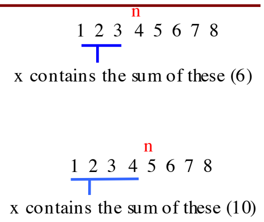
- **assertion**: true-false statement placed in a program to *assert* that it is true at that point
  - Can either be a **comment**, or an **assert** command
- **invariant**: assertion supposed to "always" be true
  - If temporarily invalidated, must make it true again
  - **Example**: class invariants 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