

Beyond Sequences: The while-loop

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

Vs For-Loop

- Broader notion of loop
 - You define “more to do”
 - Not limited sequences
- Must manage loop var
 - You create it before loop
 - You update it inside loop
 - For-loop automated it
- Trickier to get right

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while Versus for

For-Loop	While-Loop
<pre>def sum_squares(n): """Rets: sum of squares Prec: n is int > 0""" total = 0 for x in range(n): total = total + x*x</pre>	<pre>def sum_squares(n): """Rets: sum of squares Prec: n is int > 0""" total = 0 x = 0 while x < n: total = total + x*x x = x+1</pre>

Must remember to increment

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Tracing While-Loops

```
print('Before while')
total = 0
x = 0
while x < n:
    print('Start loop '+str(x))
    total = total + x*x
    x = x + 1
    print('End loop ')
print('After while')
```

Important

Output:

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

Important

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How to Design While-Loops

- Many of the same rules from for-loops
 - Often have an **accumulator variable**
 - Loop body adds to this accumulator
- Differences are loop variable and iterable
 - Typically **do not have iterable**
- Breaks up into three **design patterns**
 1. Replacement to range()
 2. Explicit goal condition
 3. Boolean tracking variable

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Replacing the Range Iterable

range(a,b)	range(c,d+1)
<pre>i = a while i <= b: process integer i i = i + 1</pre>	<pre>i = c while i <= d: process integer i i = i + 1</pre>

```
# 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]
```

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

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Using the Goal as a Condition

```
def prompt(prompt,valid):
    """Returns: the choice from a given prompt.
    Preconditions: prompt is a string, valid is a tuple of strings"""
    response = input(prompt)
    # Continue to ask while the response is not valid.
    while not (response in valid):
        print('Invalid response. Answer must be one of')+str(valid)
        response = input(prompt)
    return response
```

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Using a Boolean Variable

```
def roll_past(goal):
    """Returns: The score from rolling a die until passing goal."""
    loop = True # Keep looping until this is false
    score = 0
    while loop:
        roll = random.randint(1,6)
        if roll == 1:
            score = 0; loop = False
        else:
            score = score + roll; loop = score < goal
    return score
```

Track the condition

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Advantages of while vs 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

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Difficulties with while

Be careful when you **modify** the loop variable

def rem3(lst): """Remove all 3's from lst""" i = 0 while i < len(lst): # no 3's in lst[0..i-1] if lst[i] == 3: del lst[i] else: i = i+1	def rem3(lst): """Remove all 3's from lst""" while 3 in lst: lst.remove(3)
---	---

Stopping point keeps changing

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

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Application: Convergence

- How to implement this function?
def sqrt(c):
 | """Returns the square root of c"""
- Consider the polynomial $f(x) = x^2 - c$
 - Value sqrt(c) is a *root* of this polynomial
- Suggests a use for **Newton's Method**
 - **Start with a guess** at the answer
 - Use calculus formula to improve guess

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The Final Result

```
def sqrt(c,err=1e-6):
    """Returns: sqrt of c with given margin of error.
    Preconditions: c and err are numbers > 0"""
    x = c/2.0
    while abs(x*x-c) > err:
        # Get x_{n+1} from x_n
        x = x/2.0+c/(2.0*x)
    return x
```

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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 to False

Disadvantages

- Performance is **slower**
 - Python optimizes for-loops
 - Cannot optimize while
- **Infinite loops** more likely
 - Easy to forget loop vars
 - Or get stop condition wrong
- **Debugging** is harder
 - Will see why in later lectures

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