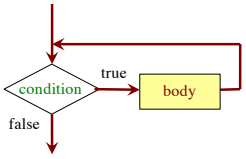
Beyond Sequences: The while-loop

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

loop condition

loop body



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

def sum_squares(n):
  """Rets: sum of squares
  Prec: n is int > 0"""
  total = 0
  for x in range(n):
  total = total + x*x
	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

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

Important

Output:

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

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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)

```
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+1)

```
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 = 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)
```

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

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

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
```

Stopping point keeps changing

```
def rem3(lst):
    """Remove all 3's from lst"""
    while 3 in lst:
        lst.remove(3)
```

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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