

Python

Control Flow

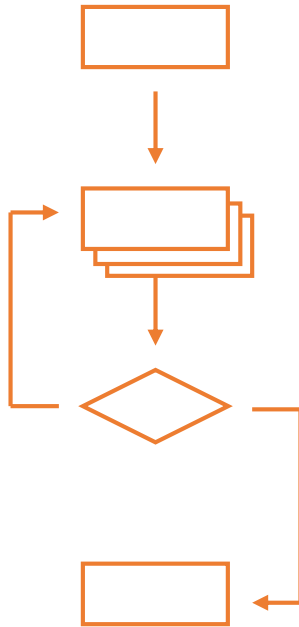
Real power of programs comes from:

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repetition

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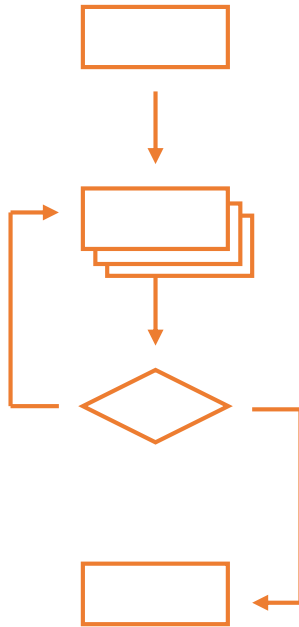
repetition



Real power of programs comes from:

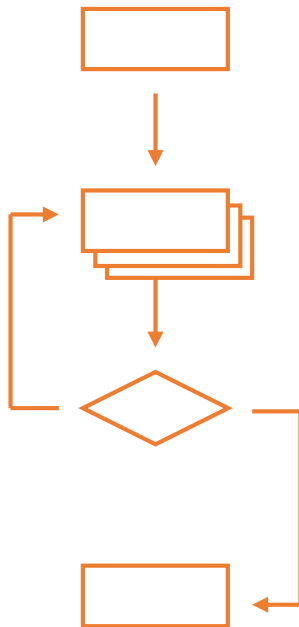
repetition

selection

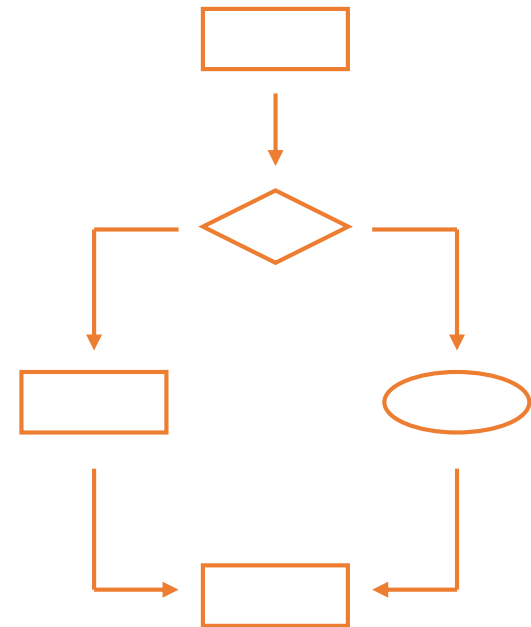


Real power of programs comes from:

repetition



selection



Simplest form of repetition is *while loop*

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```
num_moons = 3
while num_moons > 0:
    print(num_moons)
    num_moons -= 1
```


Simplest form of repetition is *while loop*

```
num_moons = 3
while num_moons > 0: ← test
    print(num_moons)
    num_moons -= 1
```

Simplest form of repetition is *while loop*

```
num_moons = 3
while num_moons > 0:
    print(num_moons)
    num_moons -= 1
```

← do

Simplest form of repetition is *while loop*

```
num_moons = 3
while num_moons > 0:
    print(num_moons)
    num_moons -= 1
```

3

← do

Simplest form of repetition is *while loop*

```
num_moons = 3
while num_moons > 0: ← test again
    print(num_moons)
    num_moons -= 1
```

3

Simplest form of repetition is *while loop*

```
num_moons = 3
while num_moons > 0:
    print(num_moons)
    num_moons -= 1
```

3

2

Simplest form of repetition is *while loop*

```
num_moons = 3
while num_moons > 0:
    print(num_moons)
    num_moons -= 1
```

3

2

1

While loop may execute zero times

While loop may execute zero times

```
print('before')
num_moons = -3
while num_moons > 0:
    print(num_moons)
    num_moons -= 1
print('after')
```


While loop may execute zero times

```
print('before')  
num_moons = -3  
while num_moons > 0: ← not true when first tested...  
    print(num_moons)  
    num_moons -= 1  
print('after')
```

While loop may execute zero times

```
print('before')  
num_moons = -3  
while num_moons > 0:  
    print(num_moons)  
    num_moons -= 1  
print('after')
```

← ...so this is never executed

While loop may execute zero times

```
print('before')
num_moons = -3
while num_moons > 0:
    print(num_moons)
    num_moons -= 1
print('after')
```

before

after

While loop may execute zero times

```
print('before')  
num_moons = -3  
while num_moons > 0:  
    print(num_moons)  
    num_moons -= 1  
print('after')  
before  
after
```

Important to consider this case when designing
and testing code

While loop may also execute forever

While loop may also execute forever

```
print('before')
num_moons = 3
while num_moons > 0:
    print(num_moons)
print('after')
```

While loop may also execute forever

```
print('before')
num_moons = 3
while num_moons > 0:
    print(num_moons)
print('after')
before
```

While loop may also execute forever

```
print('before')
num_moons = 3
while num_moons > 0:
    print(num_moons)
print('after')
```

before
3

While loop may also execute forever

```
print('before')
num_moons = 3
while num_moons > 0:
    print(num_moons)
print('after')
```

before

3

3

While loop may also execute forever

```
print('before')
num_moons = 3
while num_moons > 0:
    print(num_moons)
print('after')
```

before

3

3

3

While loop may also execute forever

```
print('before')
num_moons = 3
while num_moons > 0:
    print(num_moons)
print('after')
```

before

3

3

3

:

While loop may also execute forever

```
print('before')
```

```
num_moons = 3
```

```
while num_moons > 0:
```

```
    print(num_moons)
```

```
print('after')
```

```
before
```

```
3
```

```
3
```

```
3
```

```
⋮
```

← Nothing in here changes
the loop control condition

While loop may also execute forever

```
print('before')
num_moons = 3
while num_moons > 0:
    print(num_moons)
print('after')
```

before

3

3

3

⋮

Usually not the desired behavior...

While loop may also execute forever

```
print('before')
num_moons = 3
while num_moons > 0:
    print(num_moons)
print('after')
```

before
3
3
3
⋮

Usually not the desired behavior...

...but there *are* cases where it's useful

Why indentation?

Why indentation?

Studies show that's what people actually pay
attention to

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- Every textbook on C or Java has examples where indentation and braces don't match

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Python Style Guide (PEP 8) recommends 4 spaces

Why indentation?

Studies show that's what people actually pay attention to

- Every textbook on C or Java has examples where indentation and braces don't match

Doesn't matter how much you use, but whole block must be consistent

Python Style Guide (PEP 8) recommends 4 spaces

And no tab characters

Use `if`, `elif`, and `else` to make choices

Use if, elif, and else to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0:
    print('equal')
else:
    print('greater')
```

Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:           ← not true when first tested...
    print('less')
elif moons == 0:
    print('equal')
else:
    print('greater')
```

Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:
    print('less') ← ...so this is not executed
elif moons == 0:
    print('equal')
else:
    print('greater')
```


Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0: ← this isn't true either...
    print('equal')
else:
    print('greater')
```

Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0:
    print('equal') ← ...so this isn't executed
else:
    print('greater')
```

Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0:
    print('equal')
else:
    print('greater')
```

← nothing else has executed...

Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0:
    print('equal')
else:
    print('greater') ← ...so this is executed
```

Use if, elif, and else to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0:
    print('equal')
else:
    print('greater')
greater
```

Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0:
    print('equal')
else:
    print('greater')
greater
```

Always start with **`if`**

Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0:
    print('equal')
else:
    print('greater')
greater
```

Always start with **`if`**

Can have any number of **`elif`** clauses (including none)

Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0:
    print('equal')
else:
    print('greater')
greater
```

Always start with **`if`**

Can have any number of **`elif`** clauses (including none)

And the **`else`** clause is optional

Use `if`, `elif`, and `else` to make choices

```
moons = 3
if moons < 0:
    print('less')
elif moons == 0:
    print('equal')
else:
    print('greater')
greater
```

Always start with **if**

Can have any number of **elif** clauses (including none)

And the **else** clause is optional

Always tested in order

Blocks may contain blocks

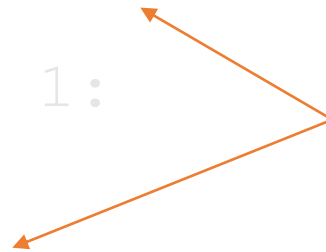
Blocks may contain blocks

```
num = 0
while num <= 10:
    if (num % 2) == 1:
        print(num)
    num += 1
```

Blocks may contain blocks

```
num = 0
while num <= 10:
    if (num % 2) == 1:
        print(num)
    num += 1
```

Count from 0 to 10



Blocks may contain blocks

```
num = 0
while num <= 10:
    if (num % 2) == 1:
        print(num) ← Print odd numbers
    num += 1
```

Blocks may contain blocks

```
num = 0
while num <= 10:
    if (num % 2) == 1:
        print(num)
    num += 1
```

1
3
5
7
9

A better way to do it

A better way to do it

```
num = 1
while num <= 10:
    print(num)
    num += 2
```


A better way to do it

```
num = 1
while num <= 10:
    print(num)
    num += 2
```

1
3
5
7
9

Stop here

Print primes less than 1000


Print primes less than 1000

```
num = 2
while num <= 1000:
    ...figure out if num is prime...
    if is_prime:
        print(num)
    num += 1
```

Print primes less than 1000

```
num = 2
while num <= 1000:
    ...figure out if num is prime...
    if is_prime:
        print(num)
    num += 1
```

Cannot be evenly divided
by any other integer



Print primes less than 1000

```
num = 2
while num <= 1000:
    ...figure out if num is prime...
    if is_prime:
        print(num)
    num += 1
```

↙

```
    is_prime = True
    trial = 2
    while trial < num:
        if ...num divisible by trial...:
            is_prime = False
        trial += 1
```

Print primes less than 1000

```
num = 2
while num <= 1000:
    ...figure out if num is prime...
    if is_prime:
        print(num)
    num += 1
```

is_prime = **True**

trial = 2

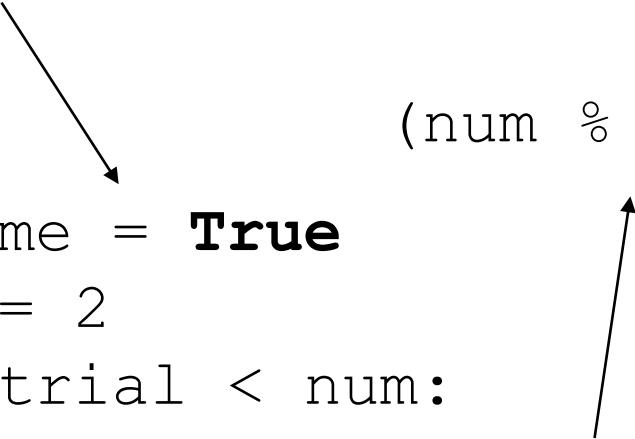
```
while trial < num:
    if ...num divisible by trial...:
        is_prime = False
    trial += 1
```

Remainder is zero

Print primes less than 1000

```
num = 2
while num <= 1000:
    ...figure out if num is prime...
    if is_prime:
        print(num)
    num += 1
    is_prime = True
    trial = 2
    while trial < num:
        if ...num divisible by trial...:
            is_prime = False
        trial += 1
```

(num % trial) == 0



Print primes less than 1000

```
num = 2
while num <= 1000:
    is_prime = True
    trial = 2
    while trial < num:
        if (num % trial) == 0:
            is_prime = False
            trial += 1
    if is_prime:
        print(num)
    num += 1
```

A more efficient way to do it

A more efficient way to do it

```
num = 2
while num <= 1000:
    is_prime = True
    trial = 2
    while trial**2 < num:
        if (num % trial) == 0:
            is_prime = False
        trial += 1
    if is_prime:
        print(num)
    num += 1
```

A more efficient way to do it

```
num = 2
while num <= 1000:
    is_prime = True
    trial = 2
    while trial**2 < num:
        if (num % trial) == 0:
            is_prime = False
            trial += 1
        else:
            trial += 1
    if is_prime:
        print(num)
    num += 1
```

← N cannot be divided
evenly by any number
greater than \sqrt{N}

Any code that hasn't been tested is probably wrong

Any code that hasn't been tested is probably wrong

```
num = 2
while num <= 10:
    is_prime = True
    trial = 2
    while trial**2 < num:
        if (num % trial) == 0:
            is_prime = False
        trial += 1
    if is_prime:
        print(num)
    num += 1
```

Any code that hasn't been tested is probably wrong

<pre>num = 2</pre>	2
<pre>while num <= 10:</pre>	3
<pre> is_prime = True</pre>	4
<pre> trial = 2</pre>	5
<pre> while trial**2 < num:</pre>	7
<pre> if (num % trial) == 0:</pre>	9
<pre> is_prime = False</pre>	
<pre> trial += 1</pre>	
<pre> if is_prime:</pre>	
<pre> print(num)</pre>	
<pre> num += 1</pre>	

Any code that hasn't been tested is probably wrong

```
num = 2
while num <= 10:
    is_prime = True
    trial = 2
    while trial**2 < num:
        if (num % trial) == 0:
            is_prime = False
        trial += 1
    if is_prime:
        print(num)
    num += 1
```

2

3

4

5

7

9

Any code that hasn't been tested is probably wrong

<pre>num = 2</pre>	2
<pre>while num <= 10:</pre>	3
<pre> is_prime = True</pre>	4
<pre> trial = 2</pre>	5
<pre> while trial**2 < num:</pre>	7
<pre> if (num % trial) == 0:</pre>	9
<pre> is_prime = False</pre>	
<pre> trial += 1</pre>	
<pre> if is_prime:</pre>	
<pre> print(num)</pre>	
<pre> num += 1</pre>	

Where's the bug?

Failures occur for perfect squares

Failures occur for perfect squares

```
num = 2
while num <= 10:
    is_prime = True
    trial = 2
    while trial**2 < num:
        if (num % trial) == 0:
            is_prime = False
            trial += 1
    if is_prime:
        print(num)
    num += 1
```

Failures occur for perfect squares

```
num = 2
while num <= 10:
    is_prime = True
    trial = 2
    while trial**2 < num: ← 2**2 == 4
        if (num % trial) == 0:
            is_prime = False
        trial += 1
    if is_prime:
        print(num)
    num += 1
```


Failures occur for perfect squares

```
num = 2
while num <= 10:
    is_prime = True
    trial = 2
    while trial**2 < num:
        if (num % trial) == 0:
            is_prime = False
            trial += 1
    if is_prime:
        print(num)
    num += 1
```

$2**2 == 4$

So never check to see

if $4 \% 2 == 0$

Failures occur for perfect squares

```
num = 2
while num <= 10:
    is_prime = True
    trial = 2
    while trial**2 < num:
        if (num % trial) == 0:
            is_prime = False
            trial += 1
    if is_prime:
        print(num)
    num += 1
```

$2**2 == 4$

So never check to see

if $4 \% 2 == 0$

Or if $9 \% 3 == 0$, etc.



created by

Greg Wilson

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