



香港中文大學(深圳)

The Chinese University of Hong Kong, Shenzhen

Introduction to Computer Science: Programming Methodology

Lecture 3 Flow Control

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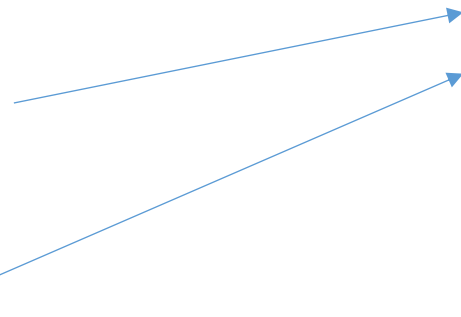
Conditional flow

Program

```
x=5  
if x<10:  
    print("smaller")  
if x>20:  
    print("bigger")  
print("finished")
```

Outputs

```
smaller  
finished  
>>> |
```



Comparison operators

- **Boolean expressions** ask a question and produce a **Yes/No** result, which we use to **control program flow**
- **Boolean expressions** use **comparison operators** to evaluate Yes/No or True/False
- **Comparison operators** check variables but do not change the values of variables
- **Careful!!** “=” is used for assignment

$x < y$	Is x less than y?
$x \leq y$	Is x less than or equal to y?
$x == y$	Is x equal to y?
$x \geq y$	Is x greater than or equal to y?
$x > y$	Is x greater than y?
$x \neq y$	Is x not equal to y?

Comparison operators

`x = 5`

`x == 5`

Comparison operators

```
x=5
if x==5:
    print("Equals 5")

if x>4:
    print("Greater than 4")

if x>=5:
    print("Greater than or equal to 5")

if x<=5:
    print("Less than or equal 5")

if x!=6:
    print("Not equal 6")
```



```
Equals 5
Greater than 4
Greater than or equal to 5
Less than or equal 5
Not equal 6
```

Examples of comparison

```
>>> 5 > 7                                # Is 5 greater than 7?
False
>>> x, y = 45, -3.0
>>> x > y                                # Is 45 greater than -3.0?
True
>>> result = x > y + 50 # Is 45 greater than -3.0 + 50?
>>> result
False
>>> if 1 + 1 > 1:
...     print("I think this should print.")
...
I think this should print.
>>> "hello" > "Bye"                       # Comparison of strings.
True
>>> "AAB" > "AAC"
False
```

Examples of comparison

```
>>> "hello" > "Bye"      # Comparison of strings.  
True  
>>> "AAB" > "AAC"  
False
```

ASCII Code

ASCII printable characters					
32	space	64	@	96	`
33	!	65	A	97	a
34	"	66	B	98	b
35	#	67	C	99	c
36	\$	68	D	100	d
37	%	69	E	101	e
38	&	70	F	102	f
39	'	71	G	103	g
40	(	72	H	104	h
41	)	73	I	105	i
42	*	74	J	106	j
43	+	75	K	107	k
44	,	76	L	108	l
45	-	77	M	109	m
46	.	78	N	110	n
47	/	79	O	111	o
48	0	80	P	112	p
49	1	81	Q	113	q
50	2	82	R	114	r
51	3	83	S	115	s
52	4	84	T	116	t
53	5	85	U	117	u
54	6	86	V	118	v
55	7	87	W	119	w
56	8	88	X	120	x
57	9	89	Y	121	y
58	:	90	Z	122	z
59	;	91	[	123	{
60	<	92	\	124	|
61	=	93	]	125	}
62	>	94	^	126	~
63	?	95	_		

Examples of comparison

```
>>> "hello" > "Bye"      # Comparison of strings.  
True  
>>> "AAB" > "AAC"  
False
```

Examples of comparison

```
>>> 7 == 7.0
```

```
True
```

```
>>> x = 0.1
```

```
>>> 1 == 10 * x
```

```
True
```

```
>>> 1 == x + x + x + x + x + x + x + x + x + x + x
```

```
False
```

```
>>> x + x + x + x + x + x + x + x + x + x + x
```

```
0.9999999999999999
```

```
>>> 7 != "7"
```

```
True
```

```
>>> 'A' == 65
```

```
False
```

Floating point math

- Floating point numbers are **approximated**
- Rational numbers (such as 0.1, which is $1/10$) whose denominator is not a power of two cannot be exactly represented
- 0.1000000000000000000000055511151231257827021181583404541015625

Boolean type

- Python contains a built-in **Boolean type**, which takes two values **True/False**



George Boole (1815 - 1864): Mathematician, inventor of mathematical logic, significant contributions to differential and difference equations

Boolean type

- Python contains a built-in **Boolean type**, which takes two values **True/False**
- Number 0 can also be used to represent **False**. All other numbers represent **True**

Bool()

```
>>> x = 0; y = 0.0; z = 0 + 0j
>>> bool(x), bool(y), bool(z)
(False, False, False)
>>> x = -1; y = 1.e-10; z = 0 + 1j
>>> bool(x), bool(y), bool(z)
(True, True, True)
>>> x = []; y = [0]; z = "0"
>>> bool(x), bool(y), bool(z)
(False, True, True)
```

One way decisions

```
x=5
print('Before 5')
if x==5:
    print('Is 5')
    print('Is still 5')
    print('Third 5')

print('Afterwards 5')

print('Before 6')
if x==6:
    print('Is 6')
    print('Is still 6')
    print('Third 6')

print('Afterwards 6')
```



```
Before 5
Is 5
Is still 5
Third 5
Afterwards 5
Before 6
Afterwards 6
```


Indentation

- **Increase indent:** indent after an **if** or **for** statement (after :)
- **Maintain indent:** to indicate the **scope** of the block (which lines are affected by the **if/for**)
- **Decrease indent:** to **back to** the level of the if statement or for

```
x=5
print(' Before 5')
if x==5:
    print(' Is 5')
    print(' Is still 5')
    print(' Third 5')

print(' Afterwards 5')
```

Indentation

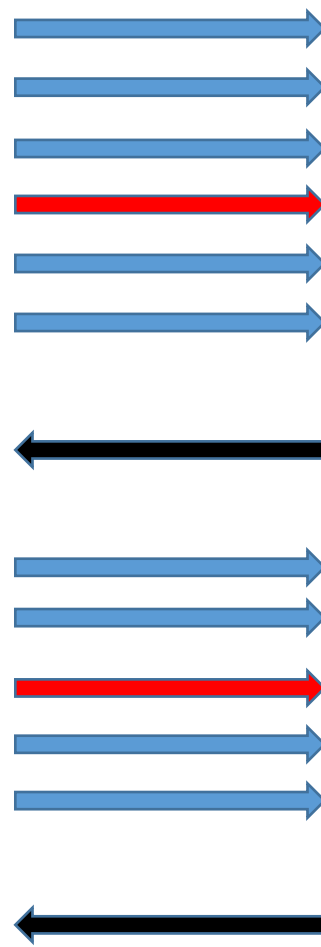
- Blank lines are ignored – they do not affect indentation
- Comments on a line by themselves are ignored w.r.t. indentation

```
x=5
print(' Before 5')
if x==5:
    print(' Is 5')
    print(' Is still 5')
    print(' Third 5')

print(' Afterwards 5')
```

Increase/maintain/decrease

- Increase/maintain after if/for statements
- Decrease to indicate the end of a block
- Blank lines and comments are ignored



The diagram illustrates the relationship between code indentation and block structure. It consists of two identical code blocks, one for the value 5 and one for the value 6. Each block is preceded by a series of horizontal arrows. The first four arrows are blue and point to the right, corresponding to the four lines of the 'if' block. The fifth arrow is red and points to the right, corresponding to the line immediately following the 'if' block. The sixth arrow is black and points to the left, corresponding to the line that starts the 'Afterwards' block. This visualizes how the 'if' block is indented, the 'Afterwards' block is at the base level, and the lines between them are at the same base level.

```
x=5
print(' Before 5' )
if x==5:
    print(' Is 5' )
    print(' Is still 5' )
    print(' Third 5' )

print(' Afterwards 5' )

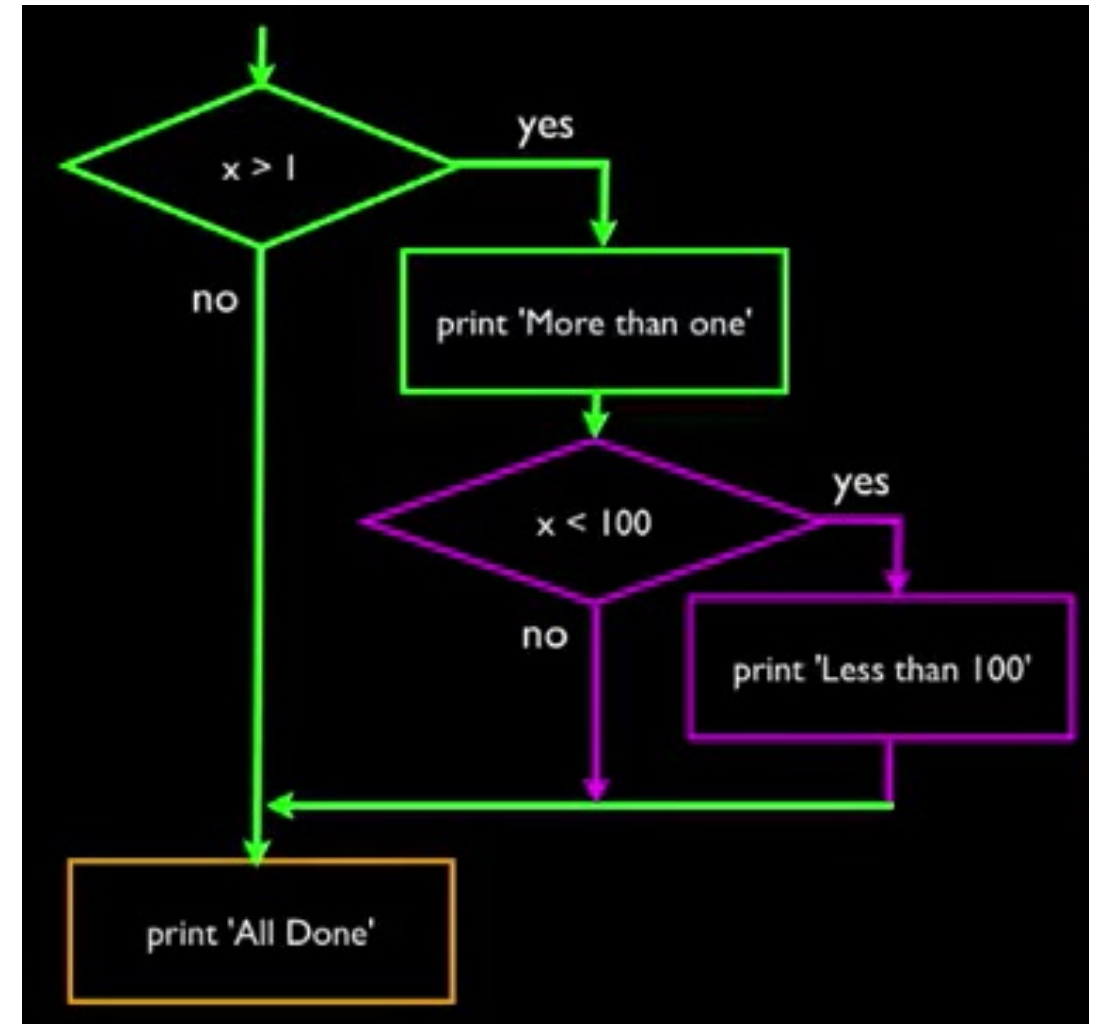
print(' Before 6' )
if x==6:
    print(' Is 6' )
    print(' Is still 6' )
    print(' Third 6' )

print(' Afterwards 6' )
```

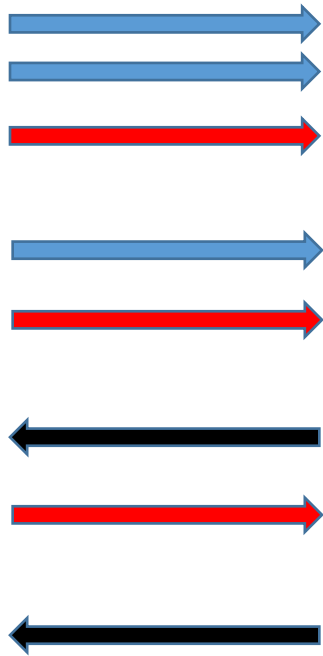
Nested decisions

Example

```
x=42
if x>1:
    print('More than 1')
    if x<100:
        print('Less than 100')
print('Finished')
```



Mental begin/end



```
x=10
if x>5:
    print('Greater than 5')

    if x>8:
        print('Greater than 8')

    if x>10:
        print('Greater than 10')

print('Finished')
```

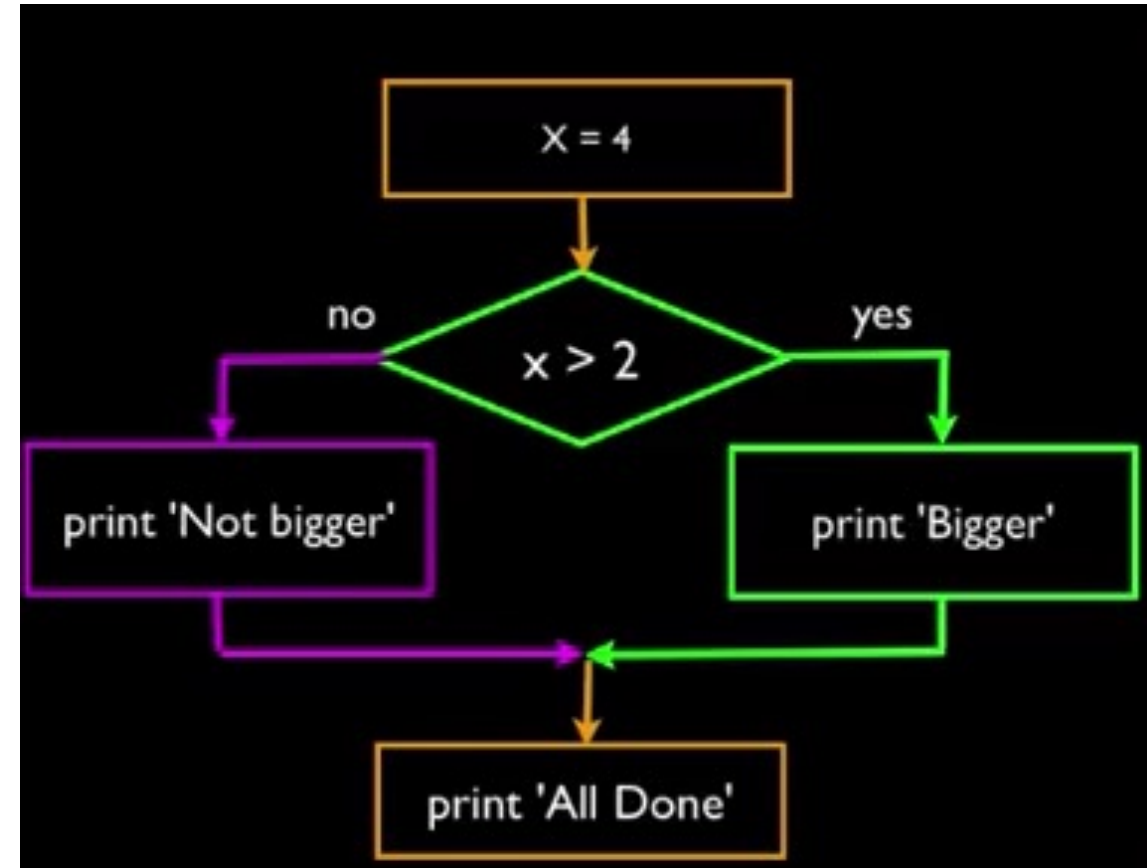
Too many nested decisions will be a disaster...

```
function register()
{
    if (!empty($_POST)) {
        $msg = '';
        if ($_POST['user_name']) {
            if ($_POST['user_password_new']) {
                if ($_POST['user_password_new'] == $_POST['user_password_repeat']) {
                    if (strlen($_POST['user_password_new']) > 5) {
                        if (strlen($_POST['user_name']) < 65 && strlen($_POST['user_name']) > 1) {
                            if (preg_match('/^[a-z\d]{2,64}$/i', $_POST['user_name'])) {
                                $user = read_user($_POST['user_name']);
                                if (!isset($user['user_name'])) {
                                    if ($_POST['user_email']) {
                                        if (strlen($_POST['user_email']) < 65) {
                                            if (filter_var($_POST['user_email'], FILTER_VALIDATE_EMAIL)) {
                                                create_user();
                                                $_SESSION['msg'] = 'You are now registered so please login';
                                                header('Location: ' . $_SERVER['PHP_SELF']);
                                                exit();
                                            } else $msg = 'You must provide a valid email address';
                                        } else $msg = 'Email must be less than 64 characters';
                                    } else $msg = 'Email cannot be empty';
                                } else $msg = 'Username already exists';
                            } else $msg = 'Username must be only a-z, A-Z, 0-9';
                        } else $msg = 'Username must be between 2 and 64 characters';
                    } else $msg = 'Password must be at least 6 characters';
                } else $msg = 'Passwords do not match';
            } else $msg = 'Empty Password';
        } else $msg = 'Empty Username';
        $_SESSION['msg'] = $msg;
    }
    return register_form();
}
```



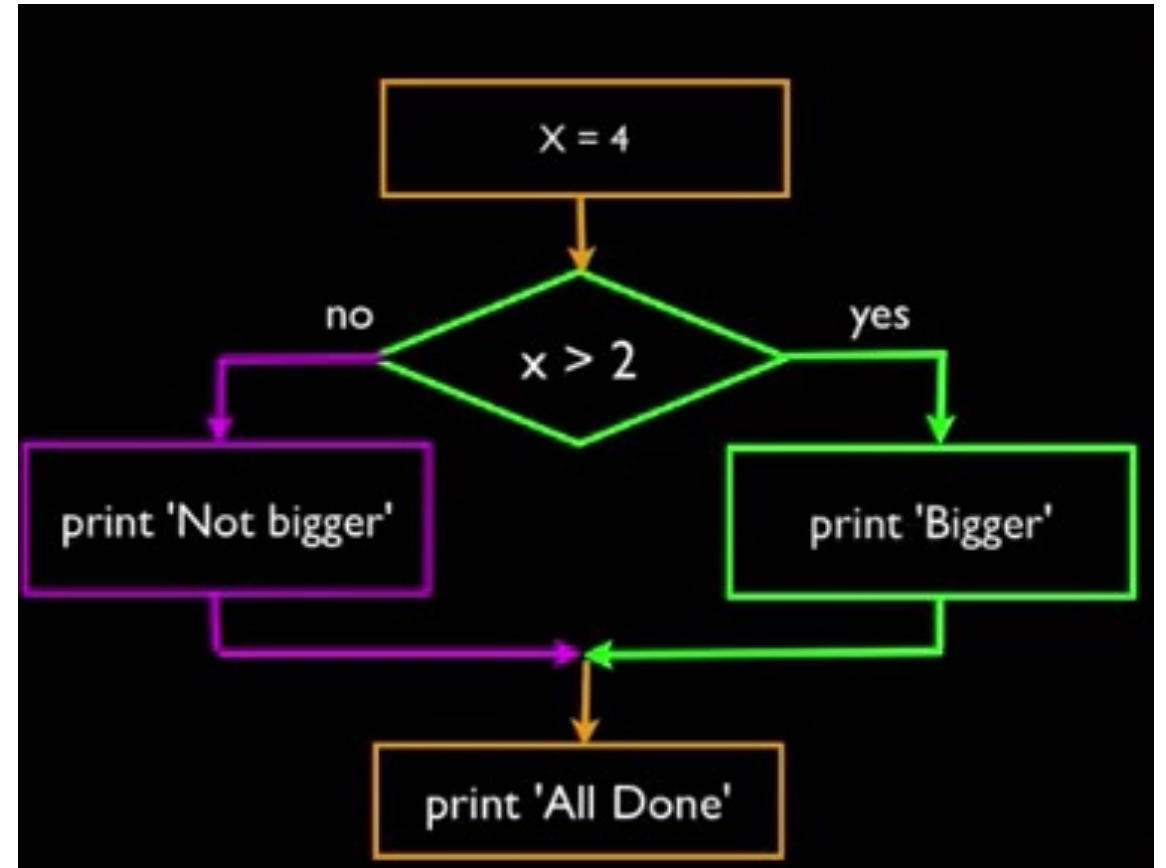
Two way decisions

- Sometimes we want to do one thing when the logical expression is true, and another thing when it is false
- It is like a fork in the road, we need to choose **one or the other path**, but **not both**



Two way decision using else

```
x=1  
  
if x>2:  
    print(' Bigger' )  
else:  
    print(' Smaller' )  
  
print(' Finished' )
```



Tips on if - else

```
x=1
```

```
if x>2:  
    print('Bigger')  
else:  
    print('Smaller')
```

```
print('Finished')
```



```
x=1
```

```
if x>2:  
    print('Bigger')  
else:  
    print('Smaller')
```

```
print('Finished')
```



- Else must come after if
- Use indentation to match if and else

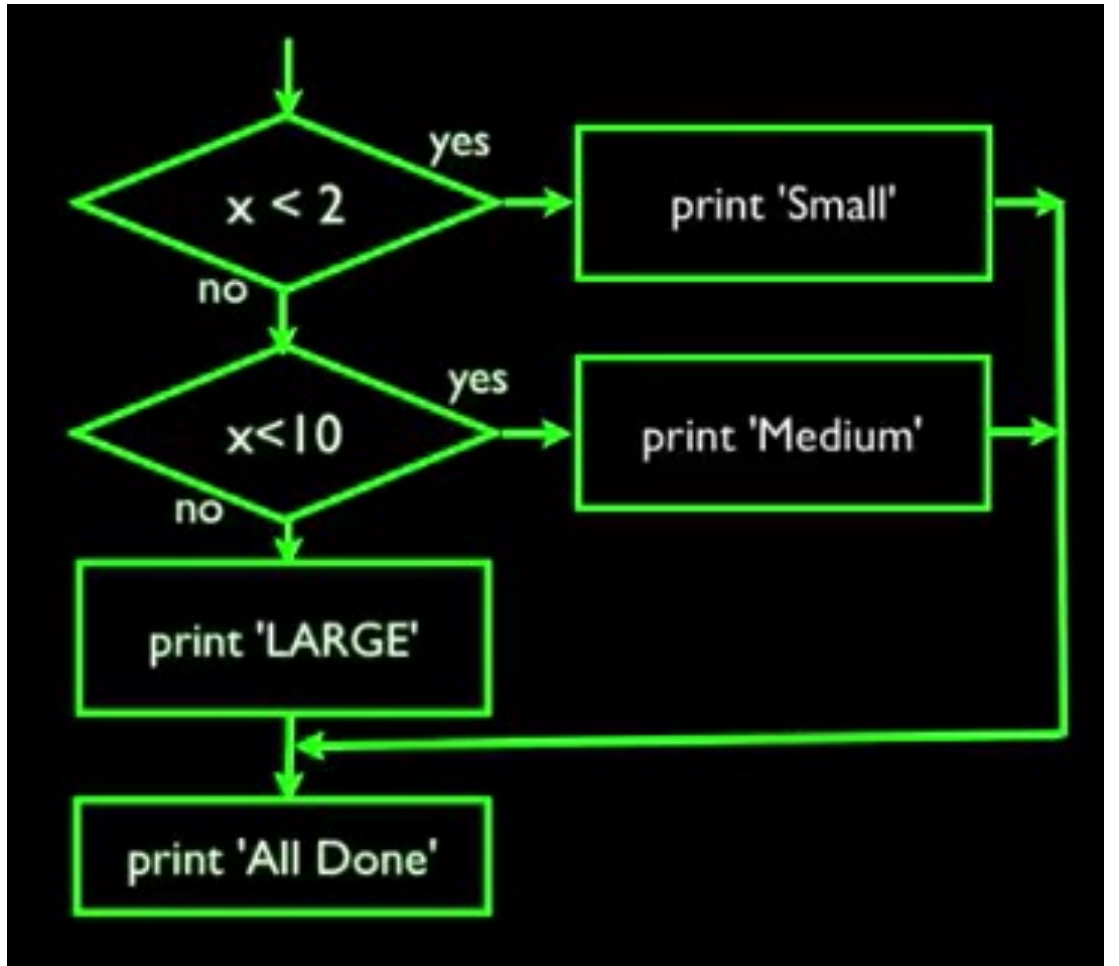
Example

```
x=1  
  
if x>2:  
    if x>5:  
        print('Bigger than 5')  
    else:  
        print('Smaller than 5')  
  
print('Finished')
```

Multi-way decisions

```
x=2
if x<2:
    print(' Small')
elif x<10:
    print(' Medium')
else:
    print(' Large')

print(' Finished')
```



Multi-way decision

```
#No else  
  
x=2  
if x<2:  
    print(' Small' )  
elif x<10:  
    print(' Medium' )  
  
print(' Finished' )
```

Multi-way decision

```
x=56
if x<2:
    print(' Small' )
elif x<10:
    print(' Medium' )
elif x<20:
    print(' Large' )
elif x<40:
    print(' Huge' )
else:
    print(' Ginormous' )

print(' Finished' )
```

Which will never be printed?

```
x=4
```

```
if x<=2:
    print('Below 2')
elif x>2:
    print('Above 2')
else:
    print('Something else')
print('Finished')
```

```
x=8
```

```
if x<2:
    print('Below 2')
elif x<20:
    print('Below 20')
elif x<10:
    print('Below 10')
else:
    print('Something else')
print('Finished')
```

Logical operators

- Logical operators can be used to combine several logical expressions into a single expression
- Python has three logical operators: not, and, or

Example

```
>>> not True
```

```
False
```

```
>>> False and True
```

```
False
```

```
>>> not False and True
```

```
True
```

```
>>> (not False) and True
```

Same as previous statement.

```
True
```

```
>>> True or False
```

```
True
```


Example

```
>>> not False or True          # Same as: (not False) or True.
True
>>> not (False or True)
False
>>> False and False or True    # Same as: (False and False) or True.
True
>>> False and (False or True)
False
```

Try/except structure

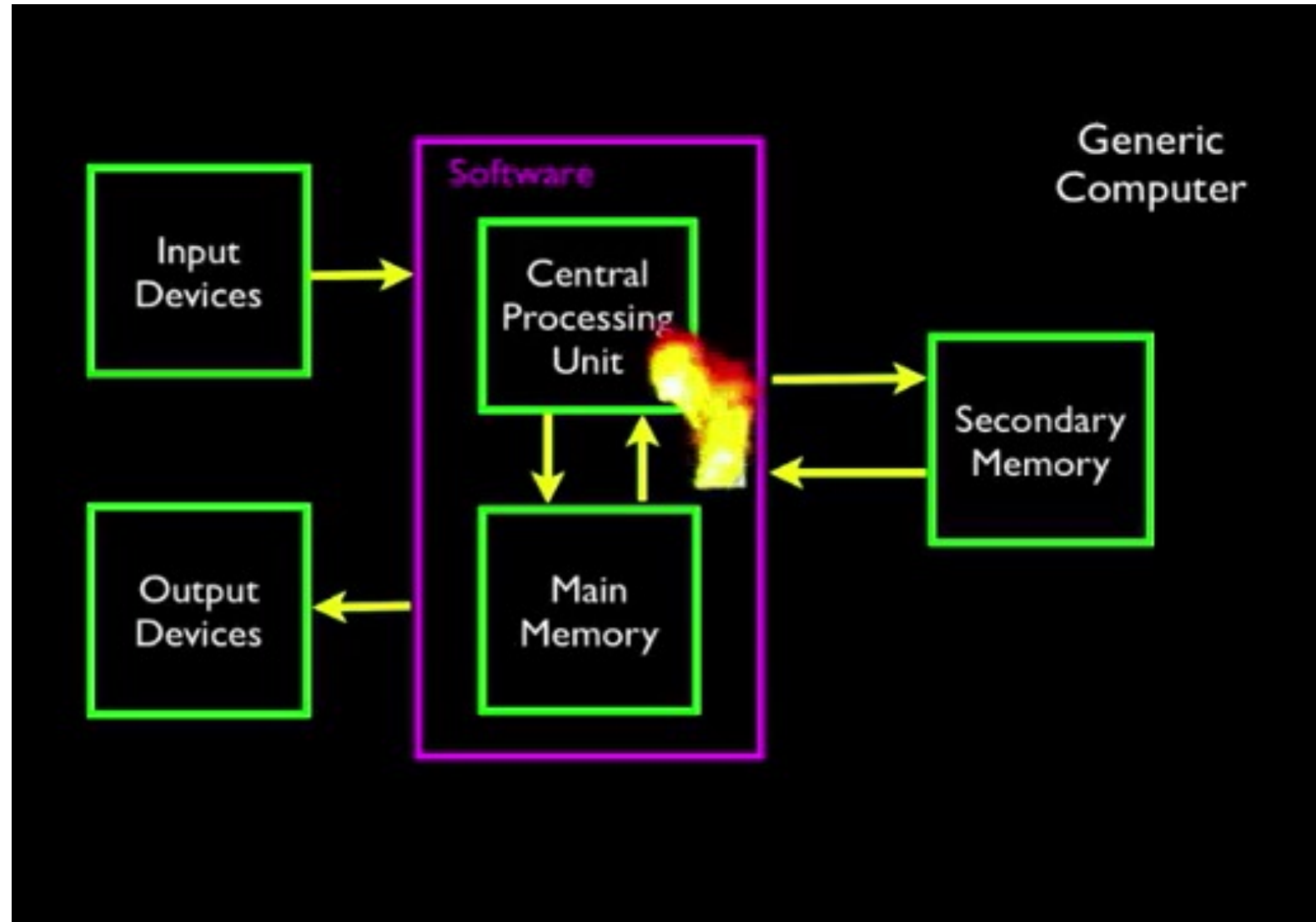
- You surround a dangerous part of code with **try/except**
- If the code in try block **works**, the except block is **skipped**
- If the code in try block **fails**, the except block will be **executed**



Example

```
astr = 'Hello bob'  
istr = int(astr)  
print('First', istr)
```

```
astr = '123'  
istr = int(astr)  
print('Second', istr)
```



Use try/except to capture errors

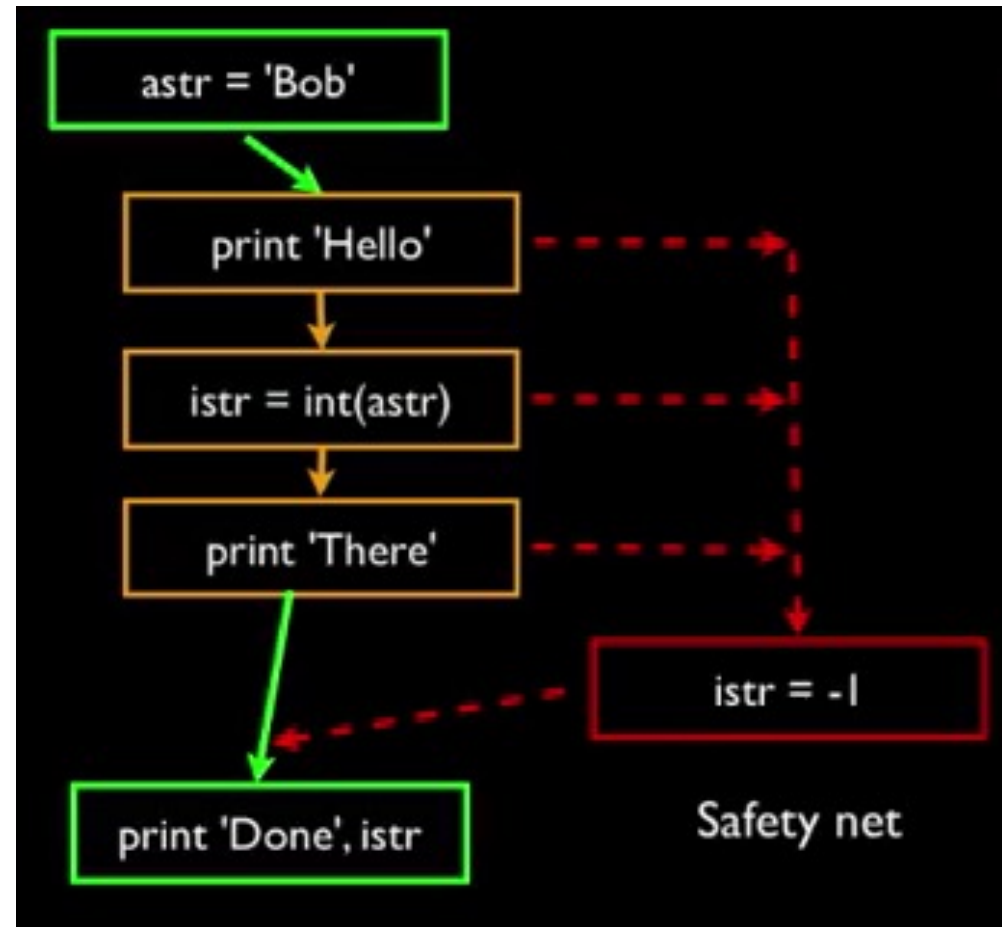
```
astr = 'Hello bob'
try:
    istr = int(astr)
except:
    istr = -1
print('First', istr)
```

```
astr = '123'
try:
    istr = int(astr)
except:
    istr = -1
print('Second', istr)
```

- When the first conversion **fails**, it just **stops into the except block**, and the program continues
- When the second conversion **succeeds**, it just **skips the except block**

Try/except

```
astr = 'Bob'
try:
    print('Hello')
    istr = int(astr)
    print('There')
except:
    istr = -1
print('Done', istr)
```



Example

```
rawstr = input('Enter a number:')

try:
    ival = int(rawstr)
except:
    ival = -1

if ival > 0:
    print('Nice work')
else:
    print('Invalid number')
```

Practice

- Write a program to instruct the user to input the working hours and hourly rate, and then output the salary. If the working hours exceed 40 hours, then the extra hours received 1.5 times pay.

Practice

- Write a program to instruct a user to input a date (both month and day), and then output the new month and day when the inputted date is advanced by one day (leap years are ignored)

Answer

```
#Add a day to a given date
```

```
month = int(input('Enter a month (1-12):'))
```

```
day = int(input('Enter a day (1-31):'))
```

```
daysInMonth = (31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31)
```

```
if day < daysInMonth[month-1]:
```

```
    print(month, day+1)
```

```
else:
```

```
    month = month%12 + 1
```

```
    print(month, 1)
```

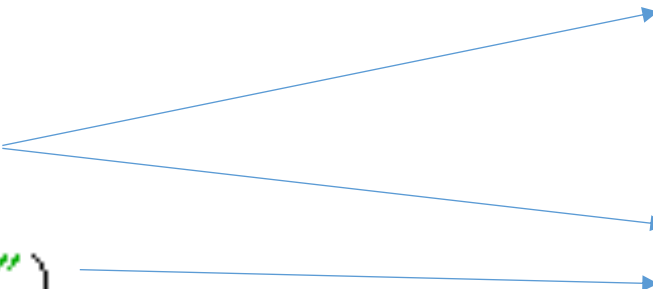
Repeated flow

Program

```
n=5
while n>0:
    print(n)
    n = n - 1
print("Finish")
```

Outputs

```
5
4
3
2
1
Finish
>>>
```



- Loops (repeated steps) have iterative variables that change each time through a loop
- Often these iterative variables go through a sequence of numbers

An infinite loop

```
n=5
while n>0:
    print(' Lather' )
    print(' Rinse' )
n=n-1
print(' Dry off!' )
```

- What is wrong with this program?

Another loop

```
n=0
while n>0:
    print(' Lather' )
    print(' Rinse' )
    n=n-1
print(' Dry off!' )
```

- What is wrong with this program?

Breaking out of a loop

- The break statement ends the current loop, and jumps to the statement which directly follows the loop

```
while (True):  
    line = input('Enter a word:')  
    if line == 'done':  
        break  
    print(line)  
print('Finished')
```

Finishing an iteration with continue

```
while True:
    line = input('Input a word:')
    if line[0] == '#': continue
    if line == 'done':
        break
    print(line)
print('Done')
```

- The **continue** statement ends the current iteration, and **start** the next iteration immediately

Indefinite loop

- **While** loops are called “indefinite loops”, since they keep going until a logical condition becomes **false**
- Till now, the loops we have seen are relatively easy to check whether they will terminate
- Sometimes it can be hard to determine whether a loop will terminate

Definite loop

- Quite often we have a finite set of items
- We can use a loop, each iteration of which will be executed for each item in the set, using the for statement
- These loops are called “definite loops” because they execute an exact number of times
- It is said that “definite loops iterate through the members of a set”

A simple for loop

Example

```
for i in [5, 4, 3, 2, 1]:  
    print(i)  
print('Finished')
```

Output

```
5  
4  
3  
2  
1  
Finished
```

For loop

Example

```
for i in [5, 4, 3, 2, 1]:  
    print(i)  
print('Finished')
```

Output

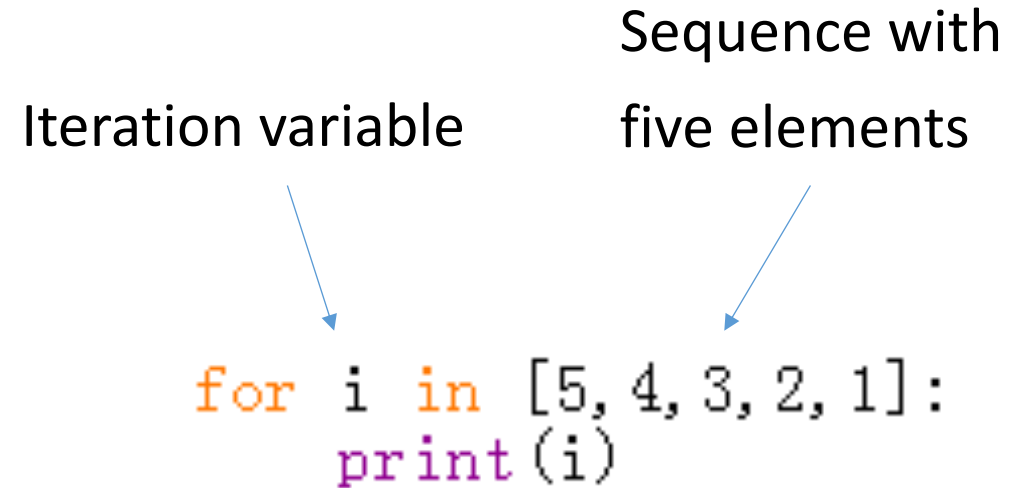
```
5  
4  
3  
2  
1  
Finished
```

- **For loops (definite loops)** have explicit iteration variables that change each time through a loop.
- These iteration variables move through a sequence or a set

In

- The iteration variable “**iterates**” through a **sequence** (ordered set)
- The block (body) of the code is executed once for each value **in** the sequence
- The **iteration variable** moves through **all** of the values in the sequence

Iteration variable Sequence with five elements



```
for i in [5, 4, 3, 2, 1]:  
    print(i)
```

Another example

Example

```
friends = ['Tom', 'Jerry', 'Bat']  
for friend in friends:  
    print('Happy new year', friend)  
print('Done')
```

Output

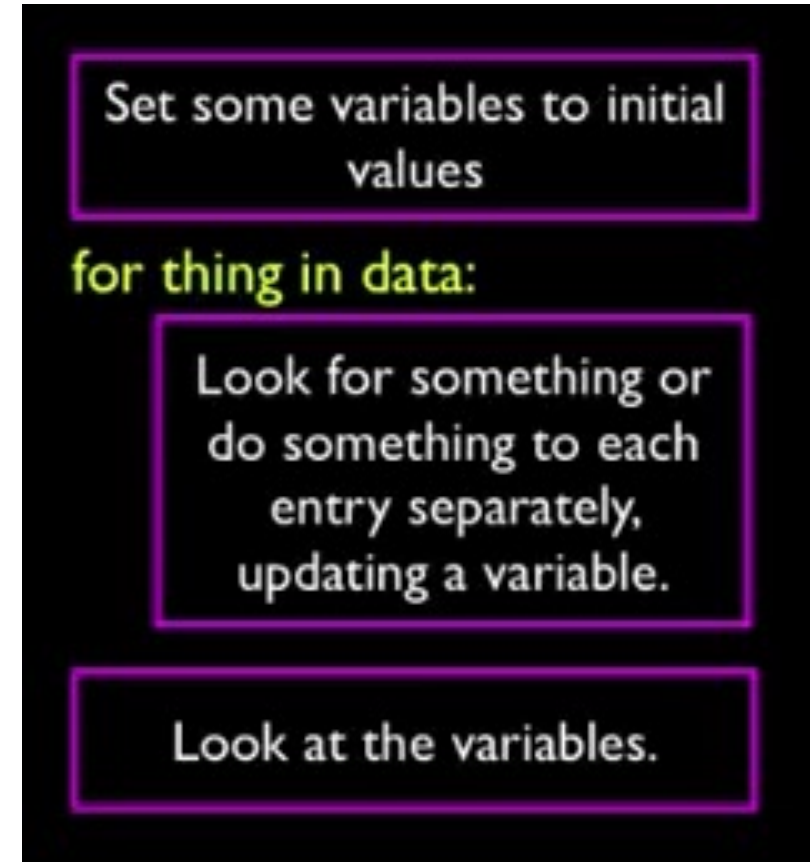
```
Happy new year Tom  
Happy new year Jerry  
Happy new year Bat  
Done
```

Loop samples

- Note: though these examples are simple, the patterns apply to all kinds of loops

Making “smart” loops

- The trick is “knowing” something about the whole loop when you are stuck writing code that only sees one entry at a time



Looping through a set

Example

```
print('Before')
for thing in [3, 5, 100, 34, 6, 87]:
    print(thing)
print('After')
```

Output

```
Before
3
5
100
34
6
87
After
```


Finding the largest number

25	1	114	117	150	152	120	46	19	126
191	121	104	116	160	105	89	125	40	14
31	139	113	94	97	193	154	140	195	122
112	163	177	48	78	101	130	83	35	197
44	54	106	143	59	38	3	41	93	81
20	164	4	11	131	0	107	71	159	69
181	178	173	148	62	142	170	72	37	145
60	187	198	99	15	82	26	8	192	17
129	73	45	9	24	188	42	151	51	183
179	79	50	76	34	33	185	102	193	184

- Use a **variable** to store the largest number we have seen so far
- If the current number is **larger**, we assign it to the store variable

Counting in a loop

Example

```
count = 0
print('Before', count)
for thing in [3, 4, 98, 38, 9, 10, 199, 78]:
    count = count + 1
    print(count, thing)
print('After', count)
```

Output

```
Before 0
1 3
2 4
3 98
4 38
5 9
6 10
7 199
8 78
After 8
```

- To count **how many times** we have executed a loop, we can introduce a counting variable, which **increases itself** in each iteration

Practice

- **Given a set of numbers, write a program to calculate their sum using for loop**

Answer

```
numberSet = [3, 4, 98, 38, 9, 10, 199, 78]
```

```
total = 0
```

```
print('Before', total)
```

```
for num in numberSet:
```

```
    total = total + num
```

```
    print(total, num)
```

```
print('Last', total)
```

```
Before 0
```

```
3 3
```

```
7 4
```

```
105 98
```

```
143 38
```

```
152 9
```

```
162 10
```

```
361 199
```

```
439 78
```

```
Last 439
```

Practice

- **Given a set of numbers, write a program to calculate their average using for loop**

Answer

```
numberSet = [3, 4, 98, 38, 9, 10, 199, 78]

total = 0
count = 0
print('Before', total)
for num in numberSet:
    total = total + num
    count = count + 1
    print(count, total, num)
print('Last', total, total/count)
```

```
Before 0
1 3 3
2 7 4
3 105 98
4 143 38
5 152 9
6 162 10
7 361 199
8 439 78
Last 439 54.875
```

Filtering in a loop

Example

```
print(' Before' )  
  
for value in [23, 3, 43, 39, 80, 111, 99, 3, 65]:  
    if value > 50:  
        print(' Large value:', value)  
  
print(' After' )
```

Output

```
Before  
Large value: 80  
Large value: 111  
Large value: 99  
Large value: 65  
After
```

- We can use an **if** statement in a loop to **catch/filter** the values we are interested at

Search using a Boolean variable

Example

```
found = False

print('Before', found)

for value in [9, 41, 12, 3, 74, 15]:
    if value == 74:
        found = True
        print(found, value)
print('After', found)
```

Output

```
Before False
False 9
False 41
False 12
False 3
True 74
True 15
After True
```

- If we want to search in a set and double check whether a specific number is in that set
- We can use a Boolean variable, set it to False at the beginning, and assign True to it as long as the target number is found

Finding the largest number

Example

```
largest_so_far = -1
print('Before', largest_so_far)

for num in [9, 39, 21, 98, 4, 5, 100, 65]:
    if num > largest_so_far:
        largest_so_far = num
        print(largest_so_far, num)

print('After', largest_so_far)
```

Output

```
Before -1
9 9
39 39
39 21
98 98
98 4
98 5
100 100
100 65
After 100
```

- Use a **variable** to store the largest number we have seen so far
- If the current number is **larger**, we assign it to the store variable

Finding the smallest number

```
smallest_so_far = -1
print('Before', smallest_so_far)

for num in [9, 39, 21, 98, 4, 5, 100, 65]:
    if num < smallest_so_far:
        smallest_so_far = num
        print(smallest_so_far, num)

print('After', smallest_so_far)
```

- Use a variable to store the smallest number we have seen so far
- If the current number is smaller, we assign it to the store variable
- What is the problem with this program?

Finding the smallest number

Example

```
smallest_so_far = None
print('Before', smallest_so_far)

for num in [9, 39, 21, 98, 4, 5, 100, 65]:
    if smallest_so_far == None:
        smallest_so_far = num
    elif num < smallest_so_far:
        smallest_so_far = num
    print(smallest_so_far, num)

print('After', smallest_so_far)
```

Output

```
Before None
9 9
9 39
9 21
9 98
4 4
4 5
4 100
4 65
After 4
```

- We still use a variable to store the **smallest value seen so far**
- In the first iteration, the smallest value is **none**, so we need to use an **if** statement to check this

The **is** and **is not** operator

```
smallest_so_far = None
print('Before', smallest_so_far)

for num in [9, 39, 21, 98, 4, 5, 100, 65]:
    if smallest_so_far is None:
        smallest_so_far = num
    elif num < smallest_so_far:
        smallest_so_far = num
    print(smallest_so_far, num)

print('After', smallest_so_far)
```

- Python has a “**is**” operator which can be used in logical expression
- Implies “**is the same as**”
- Similar to, but stronger than ==
- “**is not**” is also an operator

Is operator

Example

```
print(10 is 10)
```

```
a = 10
```

```
b = 10
```

```
print(a is b)
```

```
a = '123'
```

```
b = '123'
```

```
print(a is b)
```

```
a = [1, 2, 3]
```

```
b = [1, 2, 3]
```

```
print(a is b)
```

Output

```
True
```

```
True
```

```
True
```

```
False
```