香港中文大學(深圳)
The Chinese University of Hong Kong, Shenzhen

Introduction to Computer Science: Programming Methodology

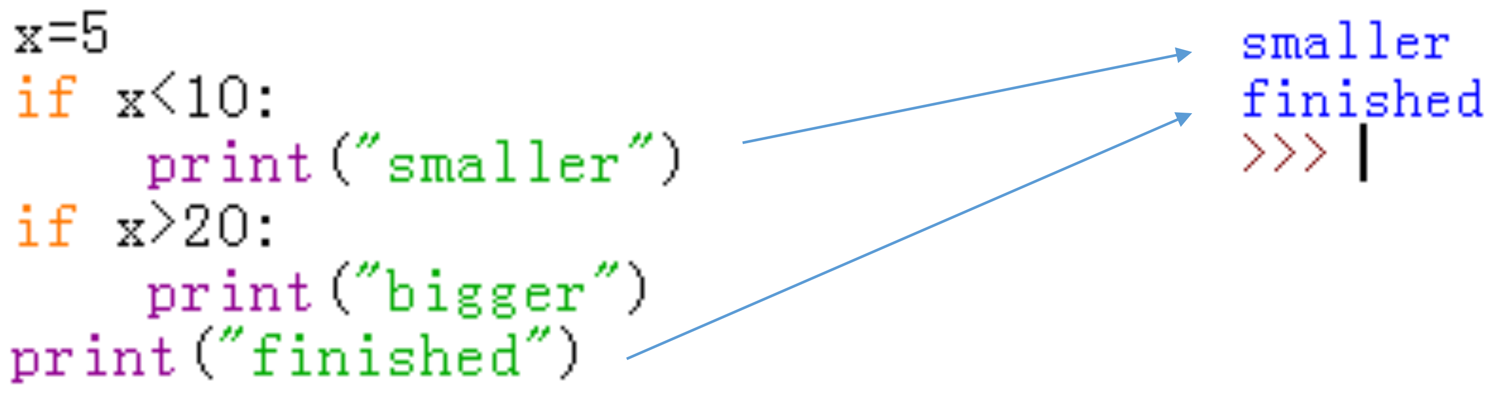
Lecture 3 Flow Control

Prof. Junhua Zhao
School of Science and Engineering

Conditional flow

Program

Outputs

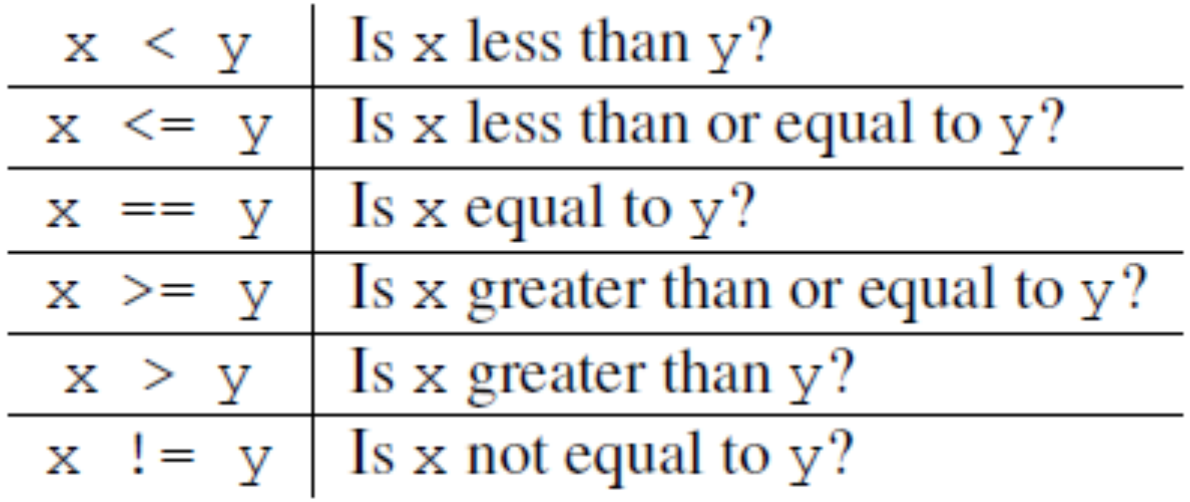


```
x=5
if x<10:
    print("smaller")
if x>20:
    print("bigger")
print("finished")
```

```
smaller
finished
>>> 
```

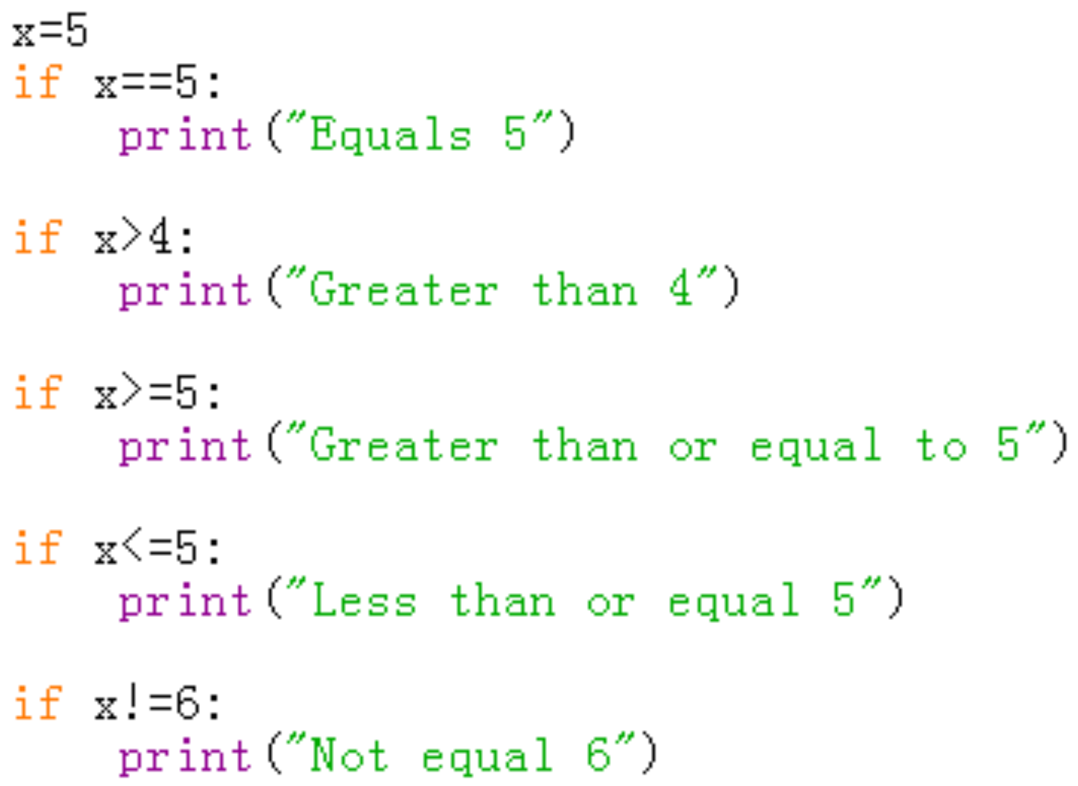
Comparison operators

- 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

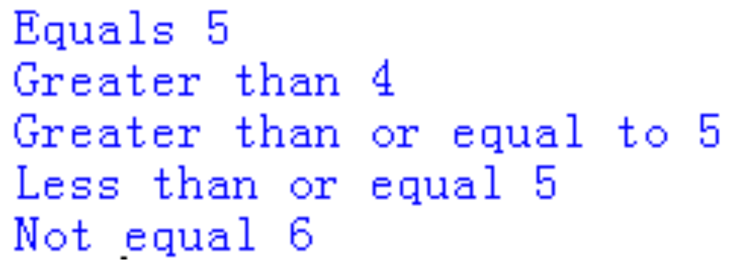


x < y	Is x less than y?
x <= y	Is x less than or equal to y?
x == y	Is x equal to y?
x >= y	Is x greater than or equal to y?
x > y	Is x greater than y?
x != y	Is x not equal to y?

Comparison operators

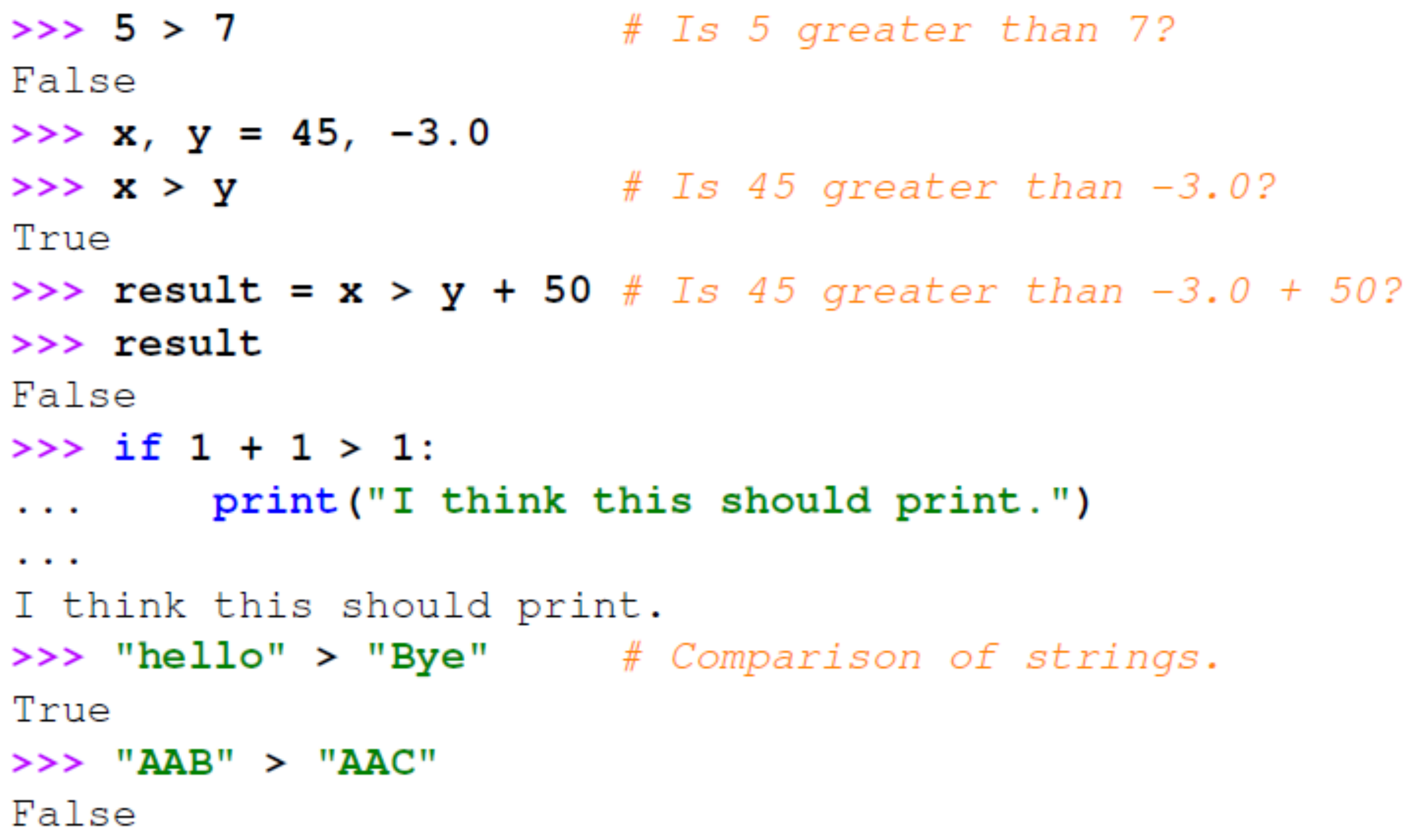


```
x=5
if x==5:
    print(“Equals 5”)

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”)
```

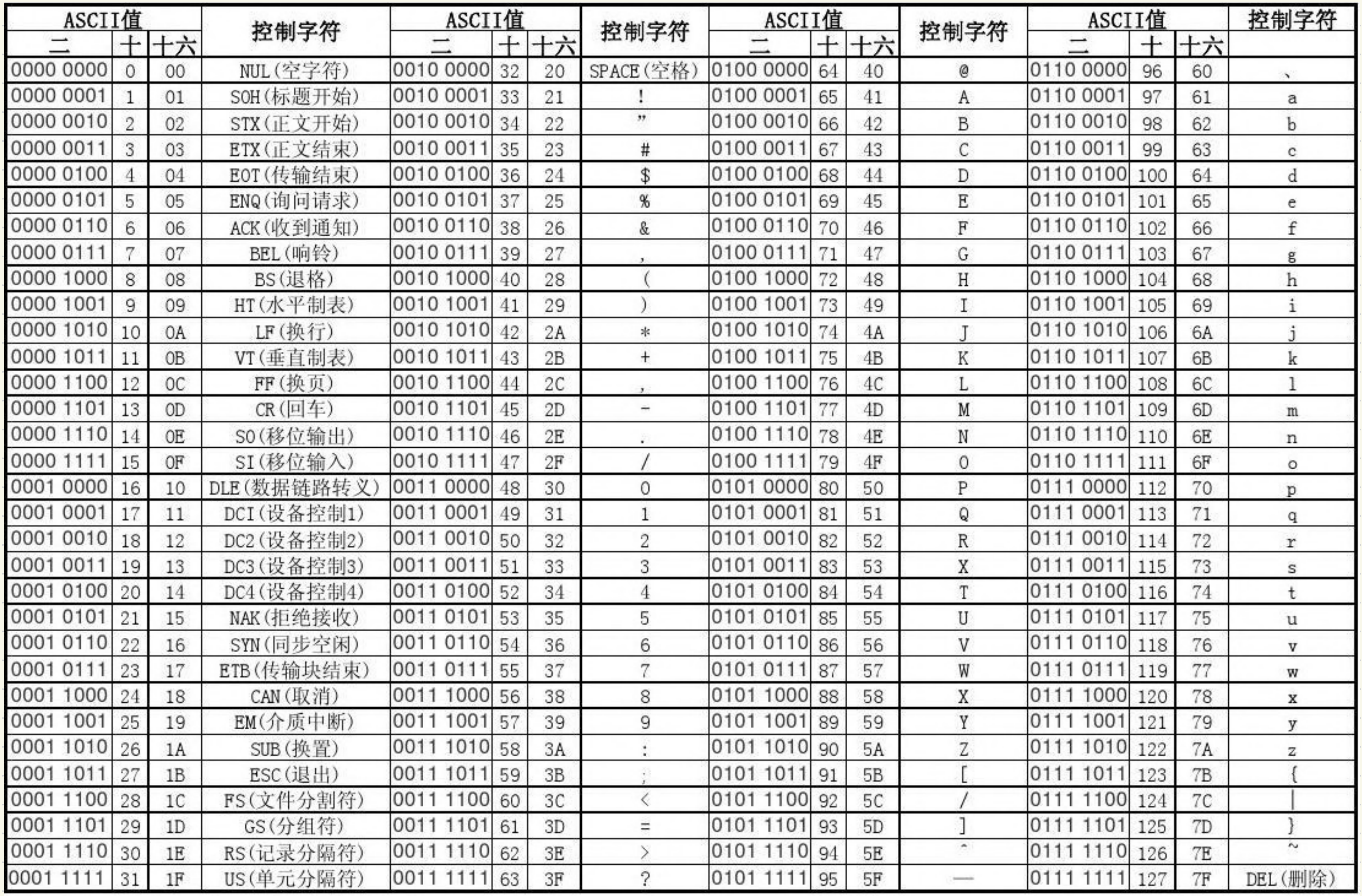


```
Equals 5
Greater than 4
Greater than or equal to 5
Less than or equal 5
Not equal 6
```

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
```



ASCII值			控制字符	ASCII值			控制字符	ASCII值			控制字符	ASCII值			控制字符
二	十	十六		二	十	十六		二	十	十六		二	十	十六	
0000 0000	0	00	NUL(空字符)	0010 0000	32	20	SPACE(空格)	0100 0000	64	40	@	0110 0000	96	60	、
0000 0001	1	01	SOH(标题开始)	0010 0001	33	21	!	0100 0001	65	41	A	0110 0001	97	61	a
0000 0010	2	02	STX(正文开始)	0010 0010	34	22	”	0100 0010	66	42	B	0110 0010	98	62	b
0000 0011	3	03	ETX(正文结束)	0010 0011	35	23	#	0100 0011	67	43	C	0110 0011	99	63	c
0000 0100	4	04	EOT(传输结束)	0010 0100	36	24	$	0100 0100	68	44	D	0110 0100	100	64	d
0000 0101	5	05	ENQ(询问请求)	0010 0101	37	25	%	0100 0101	69	45	E	0110 0101	101	65	e
0000 0110	6	06	ACK(收到通知)	0010 0110	38	26	&	0100 0110	70	46	F	0110 0110	102	66	f
0000 0111	7	07	BEL(响铃)	0010 0111	39	27	,	0100 0111	71	47	G	0110 0111	103	67	g
0000 1000	8	08	BS(退格)	0010 1000	40	28	(	0100 1000	72	48	H	0110 1000	104	68	h
0000 1001	9	09	HT(水平制表)	0010 1001	41	29	)	0100 1001	73	49	I	0110 1001	105	69	i
0000 1010	10	0A	LF(换行)	0010 1010	42	2A	*	0100 1010	74	4A	J	0110 1010	106	6A	j
0000 1011	11	0B	VT(垂直制表)	0010 1011	43	2B	+	0100 1011	75	4B	K	0110 1011	107	6B	k
0000 1100	12	0C	FF(换页)	0010 1100	44	2C	,	0100 1100	76	4C	L	0110 1100	108	6C	l
0000 1101	13	0D	CR(回车)	0010 1101	45	2D	-	0100 1101	77	4D	M	0110 1101	109	6D	m
0000 1110	14	0E	SO(移位输出)	0010 1110	46	2E	.	0100 1110	78	4E	N	0110 1110	110	6E	n
0000 1111	15	0F	SI(移位输入)	0010 1111	47	2F	/	0100 1111	79	4F	O	0110 1111	111	6F	o
0001 0000	16	10	DLE(数据链路转义)	0011 0000	48	30	0	0101 0000	80	50	P	0111 0000	112	70	p
0001 0001	17	11	DCI(设备控制1)	0011 0001	49	31	1	0101 0001	81	51	Q	0111 0001	113	71	q
0001 0010	18	12	DC2(设备控制2)	0011 0010	50	32	2	0101 0010	82	52	R	0111 0010	114	72	r
0001 0011	19	13	DC3(设备控制3)	0011 0011	51	33	3	0101 0011	83	53	X	0111 0011	115	73	s
0001 0100	20	14	DC4(设备控制4)	0011 0100	52	34	4	0101 0100	84	54	T	0111 0100	116	74	t
0001 0101	21	15	NAK(拒绝接收)	0011 0101	53	35	5	0101 0101	85	55	U	0111 0101	117	75	u
0001 0110	22	16	SYN(同步空闲)	0011 0110	54	36	6	0101 0110	86	56	V	0111 0110	118	76	v
0001 0111	23	17	ETB(传输块结束)	0011 0111	55	37	7	0101 0111	87	57	W	0111 0111	119	77	w
0001 1000	24	18	CAN(取消)	0011 1000	56	38	8	0101 1000	88	58	X	0111 1000	120	78	x
0001 1001	25	19	EM(介质中断)	0011 1001	57	39	9	0101 1001	89	59	Y	0111 1001	121	79	y
0001 1010	26	1A	SUB(换置)	0011 1010	58	3A	:	0101 1010	90	5A	Z	0111 1010	122	7A	z
0001 1011	27	1B	ESC(退出)	0011 1011	59	3B	;	0101 1011	91	5B	[	0111 1011	123	7B	{
0001 1100	28	1C	FS(文件分割符)	0011 1100	60	3C	<	0101 1100	92	5C	/	0111 1100	124	7C	|
0001 1101	29	1D	GS(分组符)	0011 1101	61	3D	=	0101 1101	93	5D	]	0111 1101	125	7D	}
0001 1110	30	1E	RS(记录分隔符)	0011 1110	62	3E	>	0101 1110	94	5E	ˆ	0111 1110	126	7E	~
0001 1111	31	1F	US(单元分隔符)	0011 1111	63	3F	?	0101 1111	95	5F	—	0111 1111	127	7F	DEL(删除)

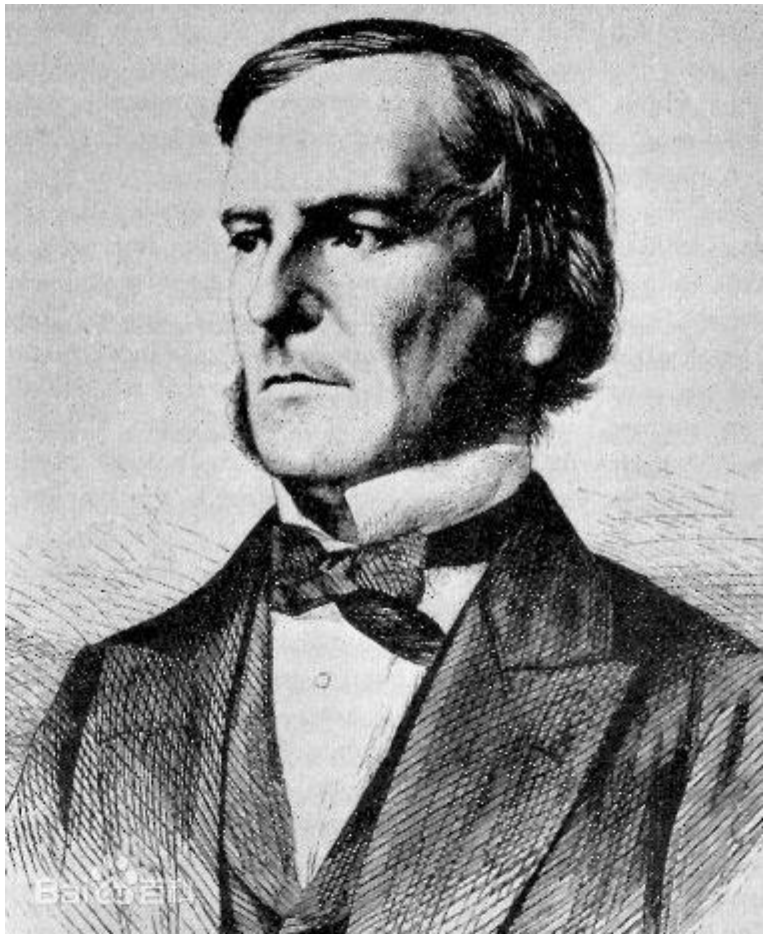
Examples of comparison

```
>>> 7 == 7.0
True
>>> x = 0.1
>>> 1 == 10 * x
True
>>> 1 == x + x + x + x + x + x + x + x + x + x
False
>>> x + x + x + x + x + x + x + x + x + x
0.9999999999999999
>>> 7 != "7"
True
>>> 'A' == 65
False
```

Numeric Error
数值误差

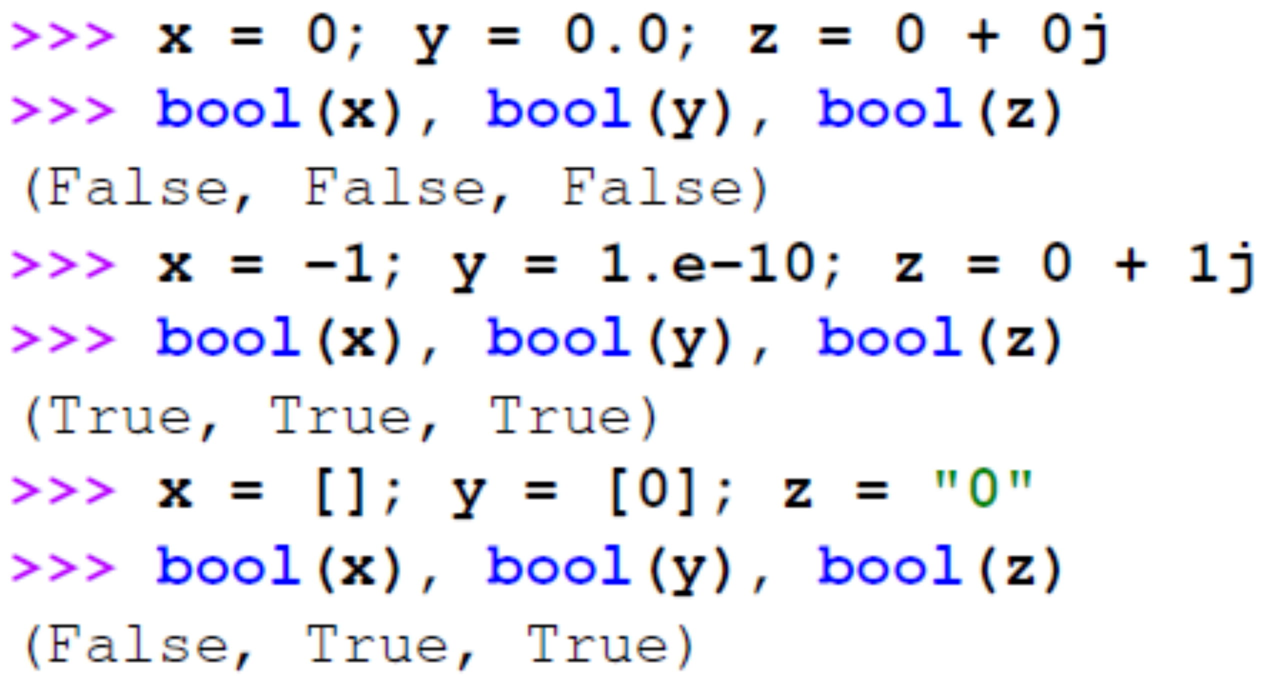
Boolean type

- 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



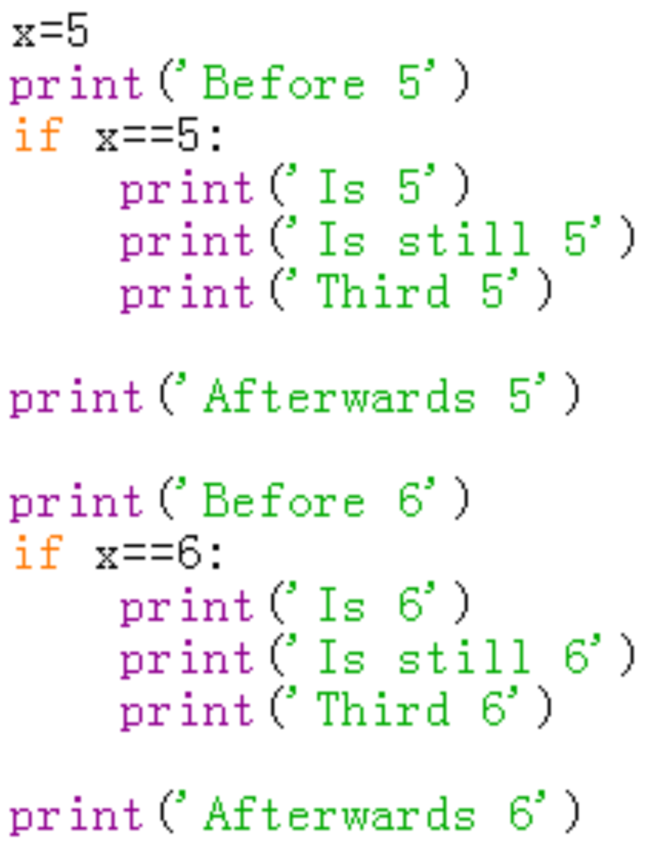
George Boole (1815 - 1864): Mathematician, inventor of mathematical logic, significant contributions to differential and difference equations

Bool()

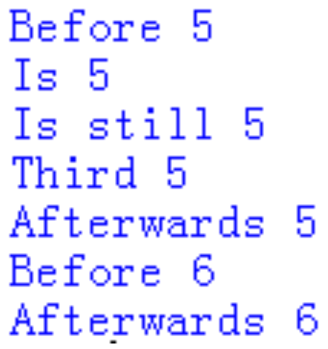


```
>>> x = 0; y = 0.0; z = 0 + 0j
>>> bool(x), bool(y), bool(z)
(False, False, False)
>>> x = -1; y = 1.e-10; z = 0 + 1j
>>> bool(x), bool(y), bool(z)
(True, True, True)
>>> x = []; y = [0]; z = "0"
>>> bool(x), bool(y), bool(z)
(False, True, True)
```

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’)
```



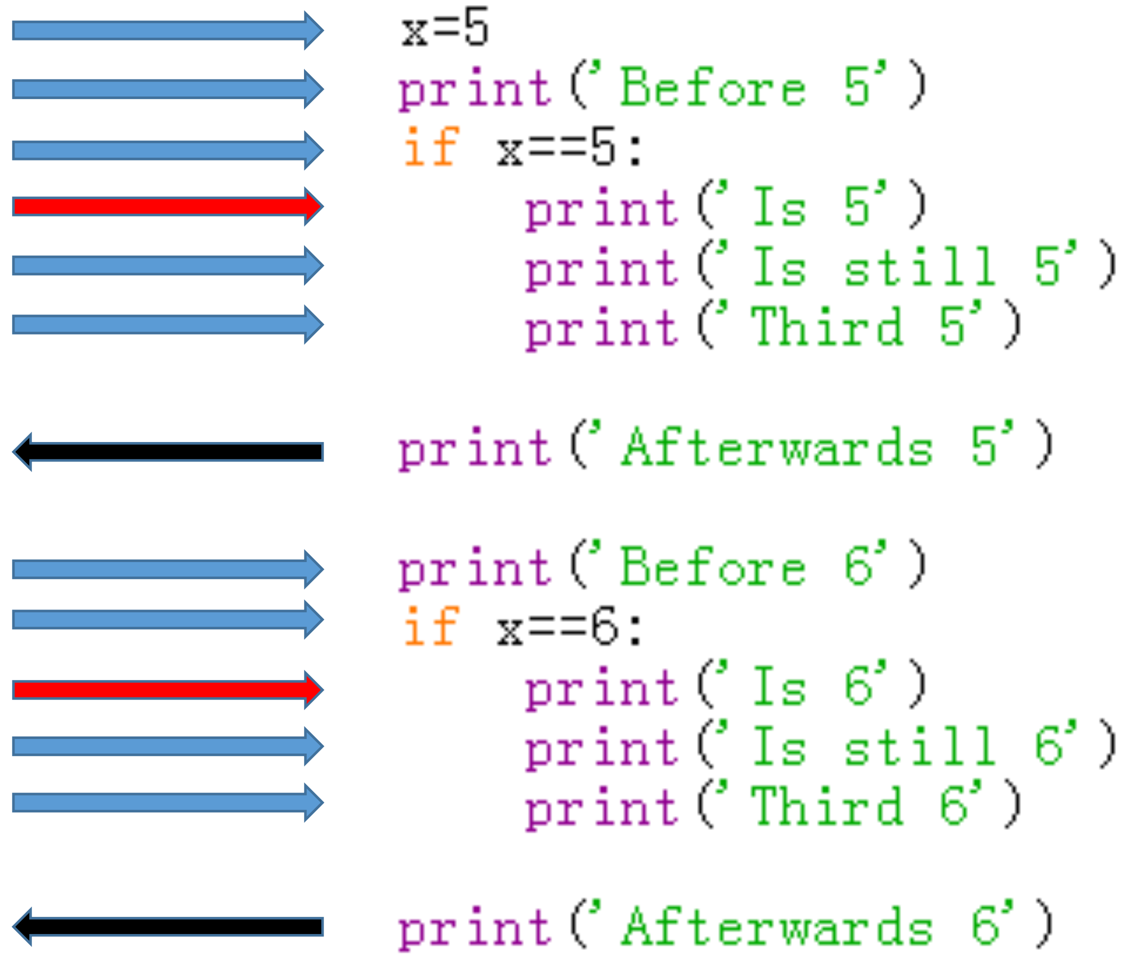
```
Before 5
Is 5
Is still 5
Third 5
Afterwards 5
Before 6
Afterwards 6
```

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 statement to indicate the end of the block
- Blank lines are ignored – they do not affect indentation
- Comments on a line by themselves are ignored w.r.t. indentation

Increase/maintain/decrease

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

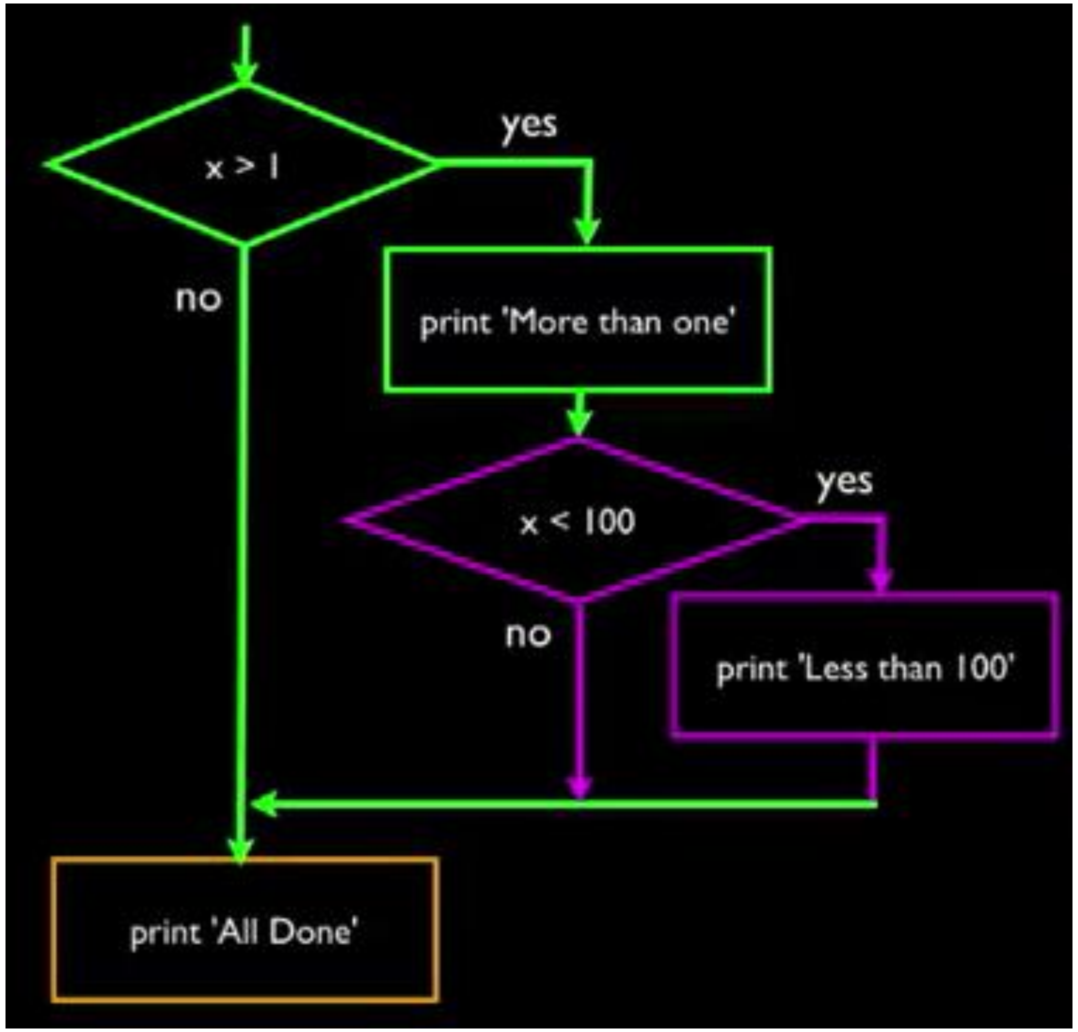


```
x=5
print('Before 5')
if x==5:
    print('Is 5')
    print('Is still 5')
    print('Third 5')

print('Afterwards 5')

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

print('Afterwards 6')
```

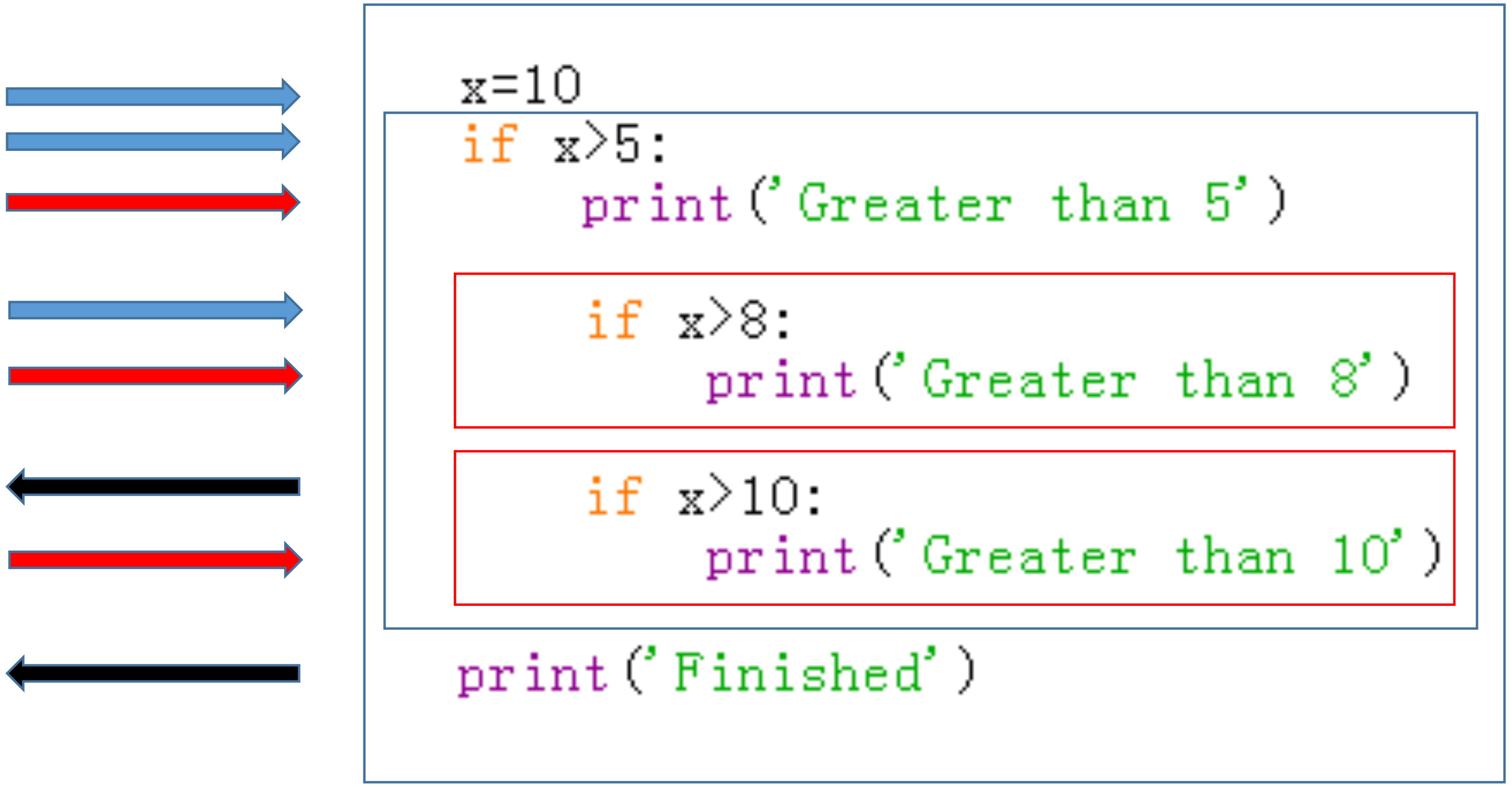
Nested decisions

Example

```
x=42
if x>1:
    print('More than 1')

    if x<100:
        print('Less then 100')

print('Finished')
```

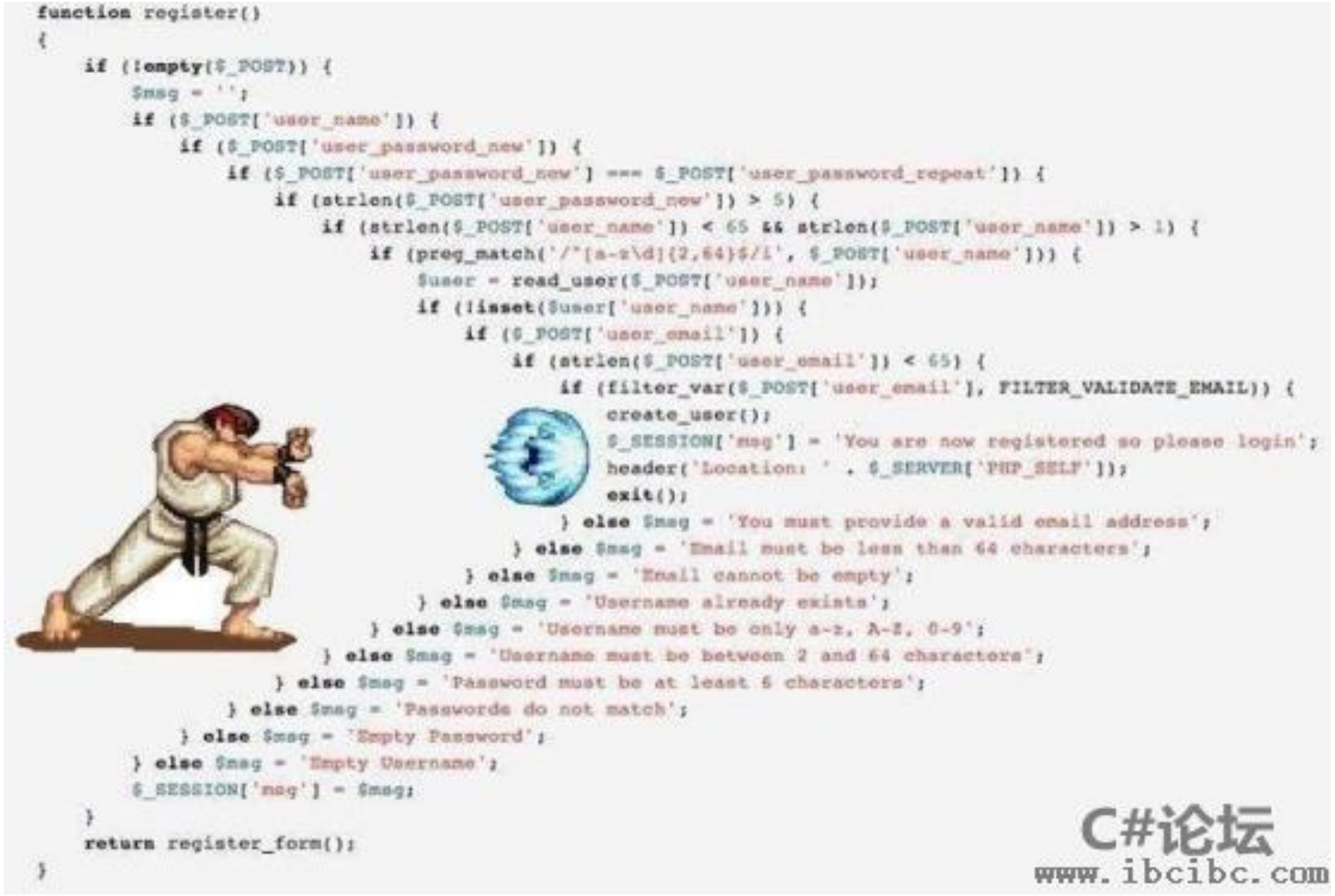


Mental begin/end



```
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')
```

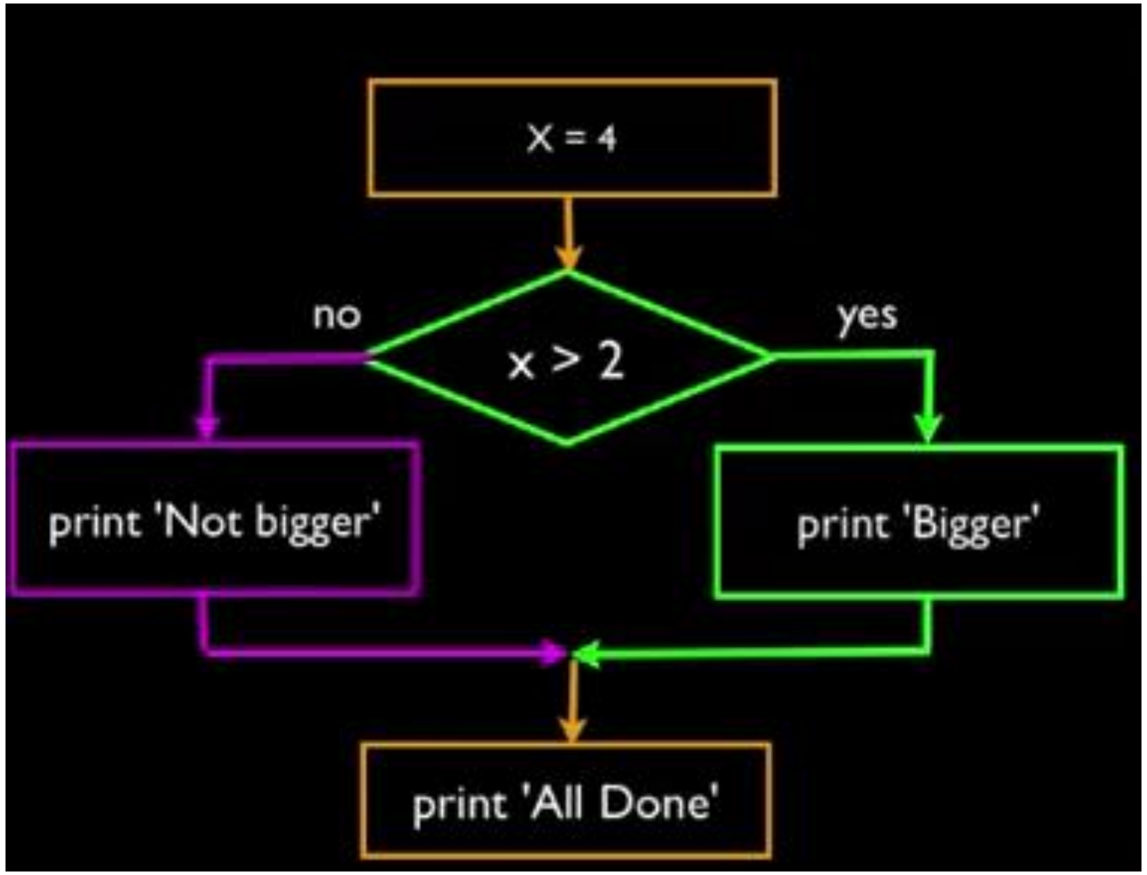
Too many nested decisions will be a disaster...



```
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

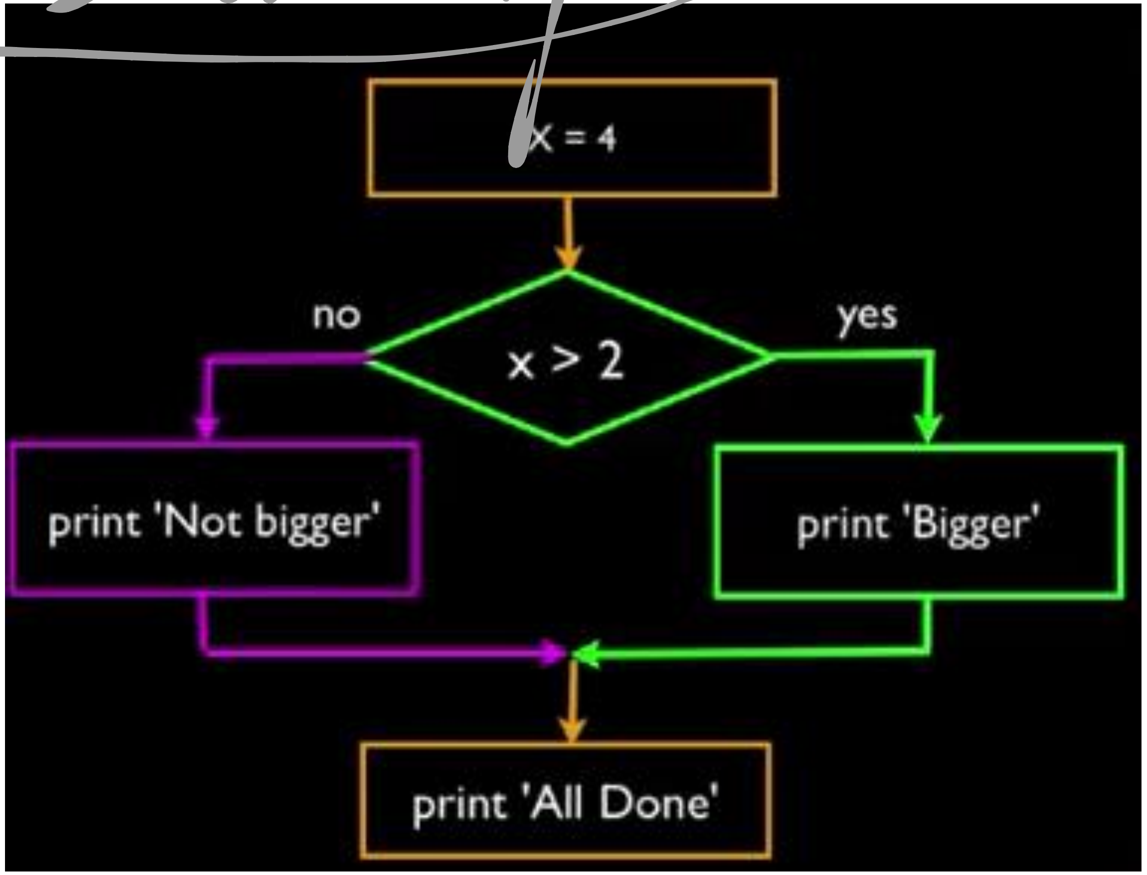
- Sometimes we want to do one thing when the logical expression is true, and another thing when it is false
- It is like a fork in the road, we need to choose one or the other path, but not both



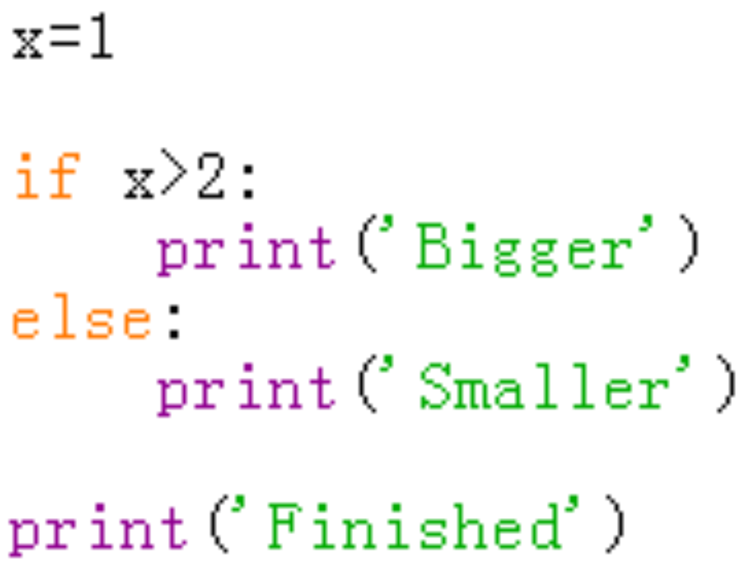
Two way decision using else

every "else" must has an "if"

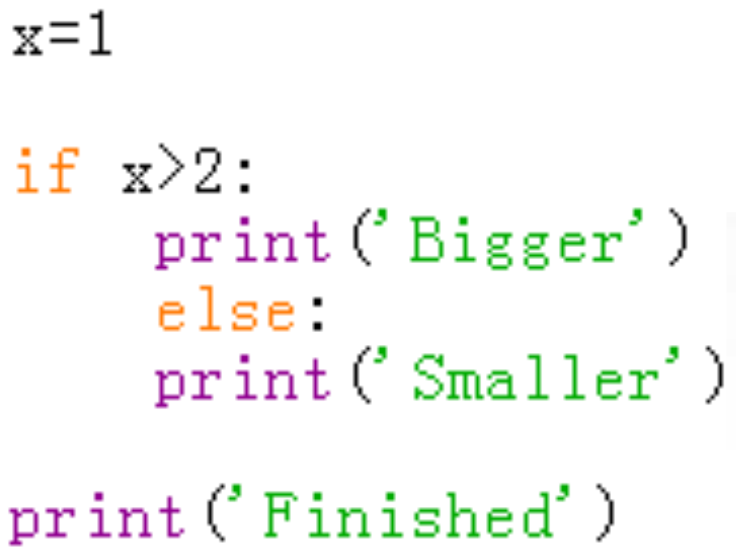
```
x=1

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’)
```

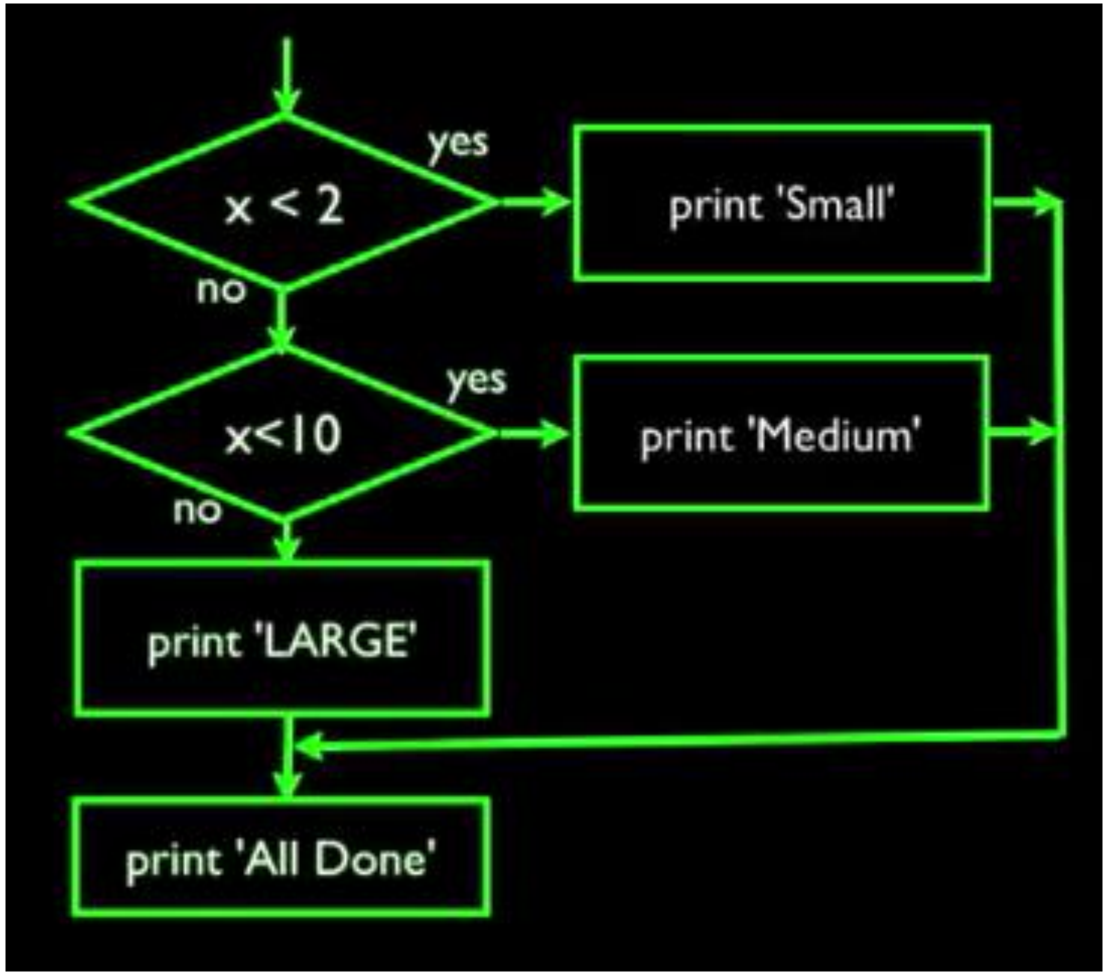
- Else must come after if
- Use indentation to match if and else

Example

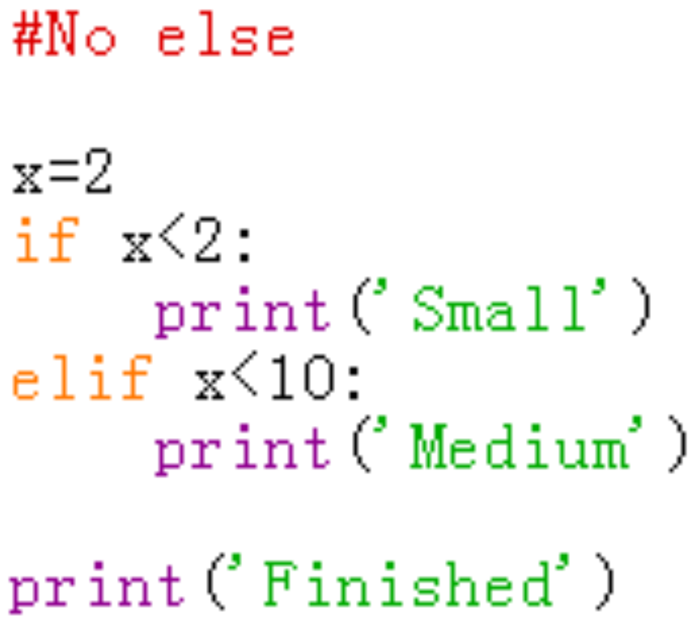
```
x=1

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')
```

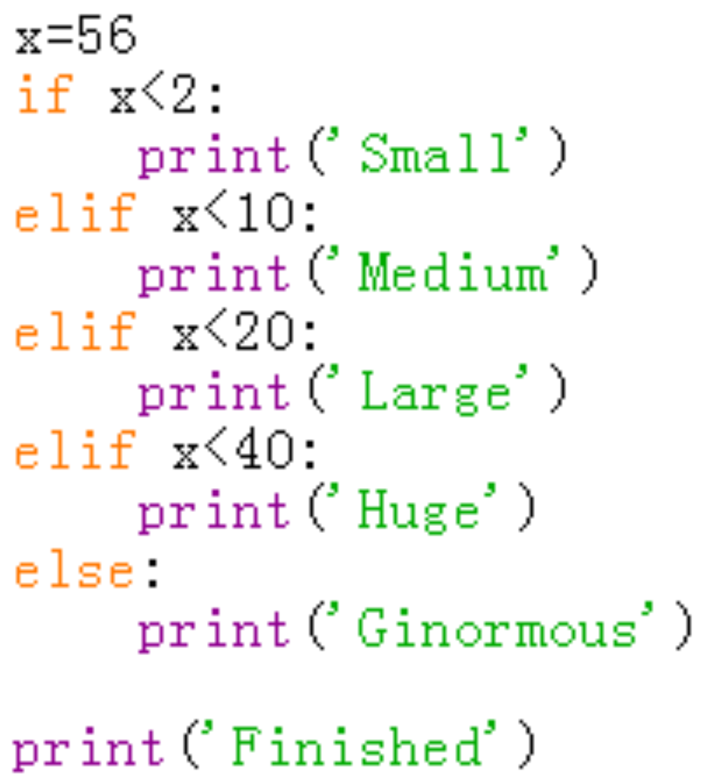


Multi-way decision



```
#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 print?

```
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

not T = F   T and T = T   T or T = T

not F = T   T and F = F   T or F = T

F and F = F   F or F = F

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
```

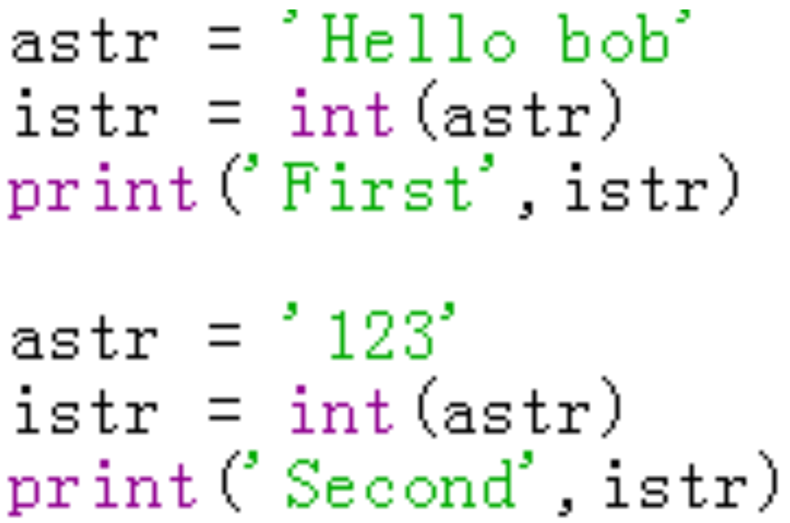
Example

```
>>> 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
```

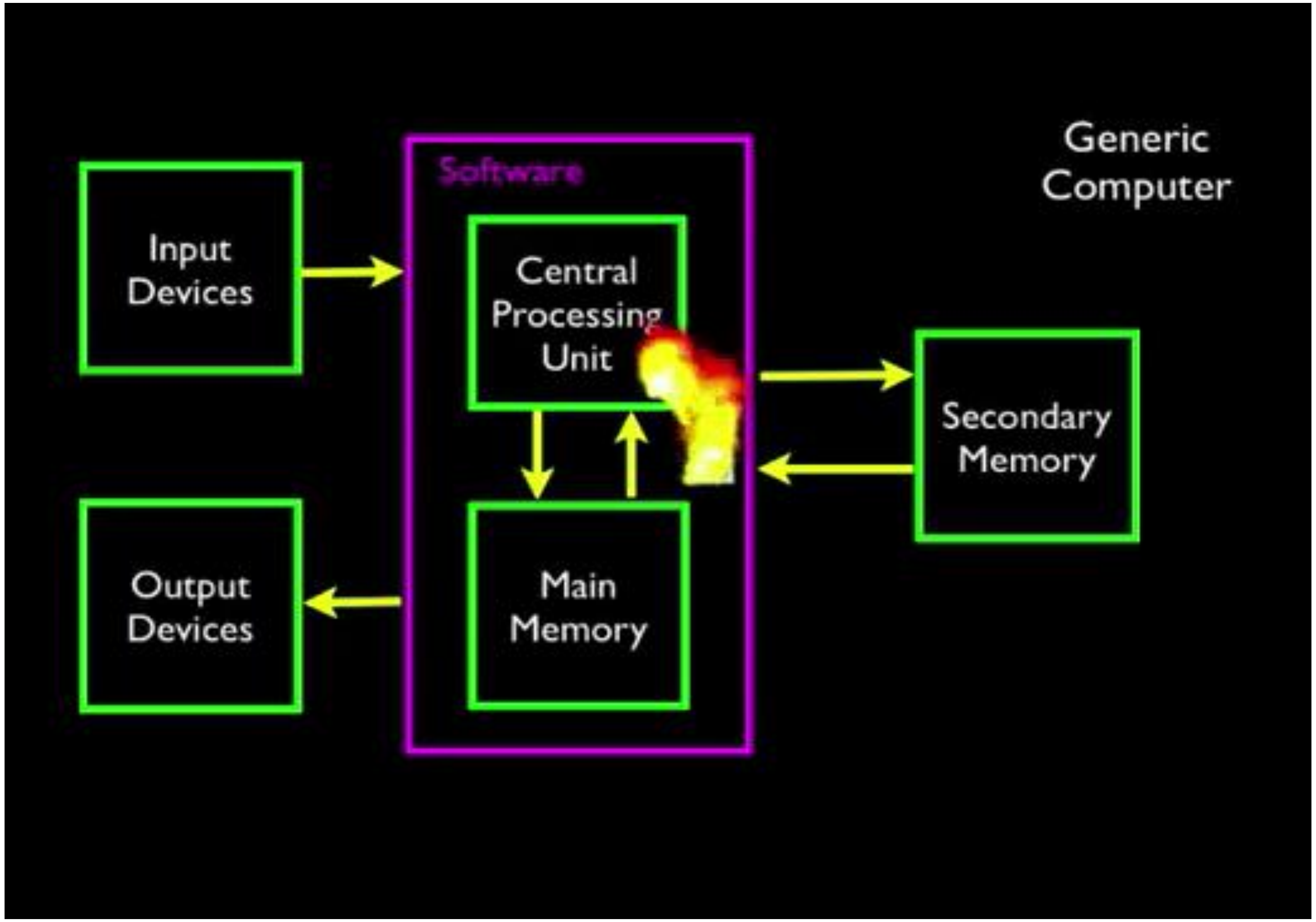
Try/except structure

- 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

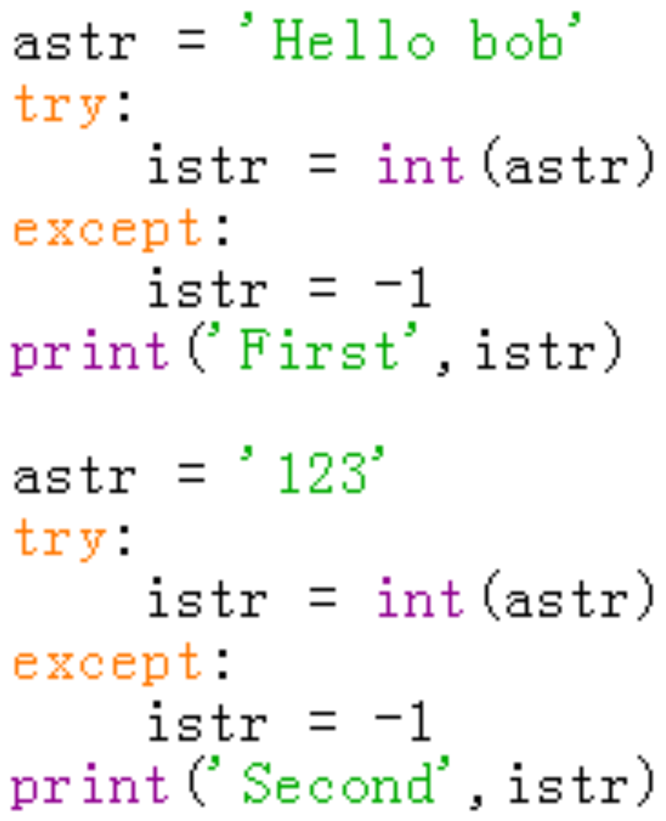
Example



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

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


Generic
Computer
Input
Devices
Software
Central
Processing
Unit
Main
Memory
Output
Devices
Secondary
Memory

Use try/except to capture errors



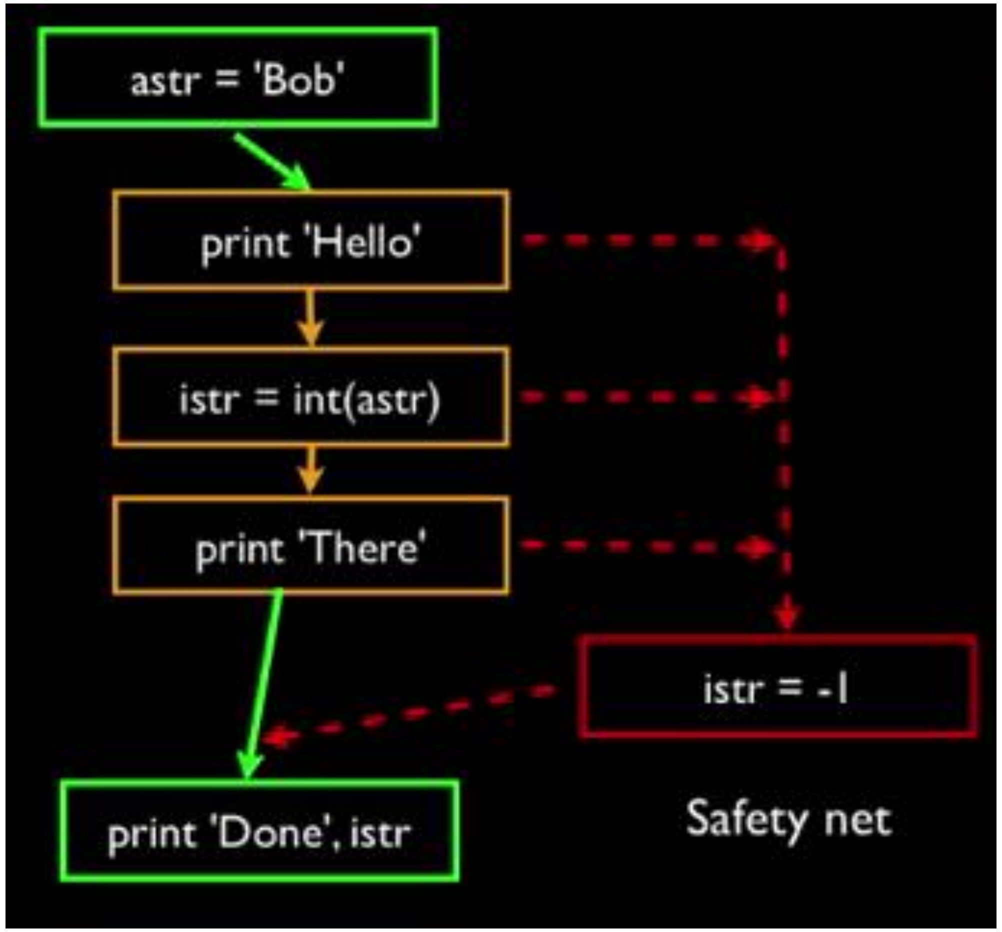
```
astr = ’Hello bob’
try:
    istr = int(astr)
except:
    istr = -1
print(’First’,istr)

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

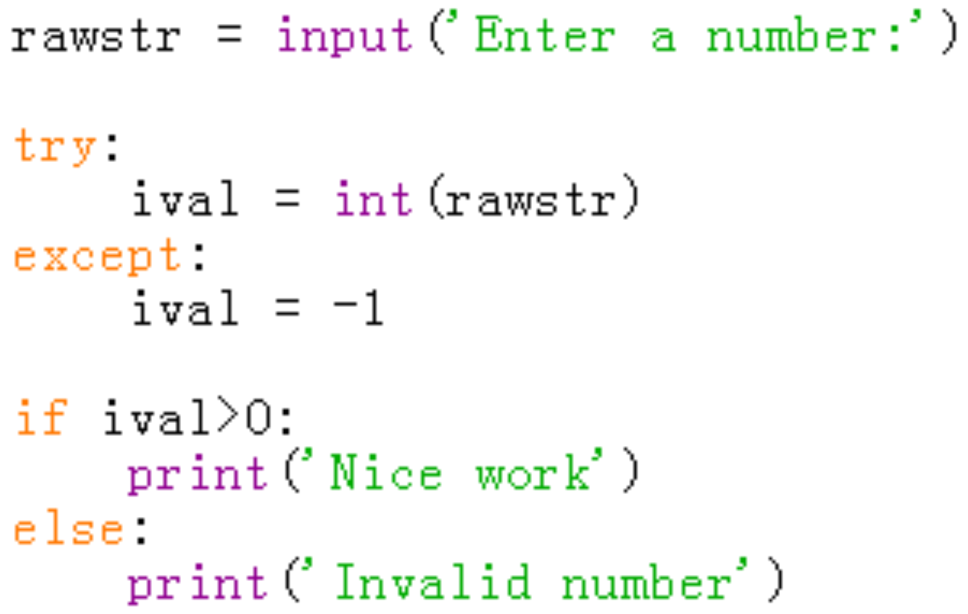
- When the second conversion succeeds, it just skips the except block

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

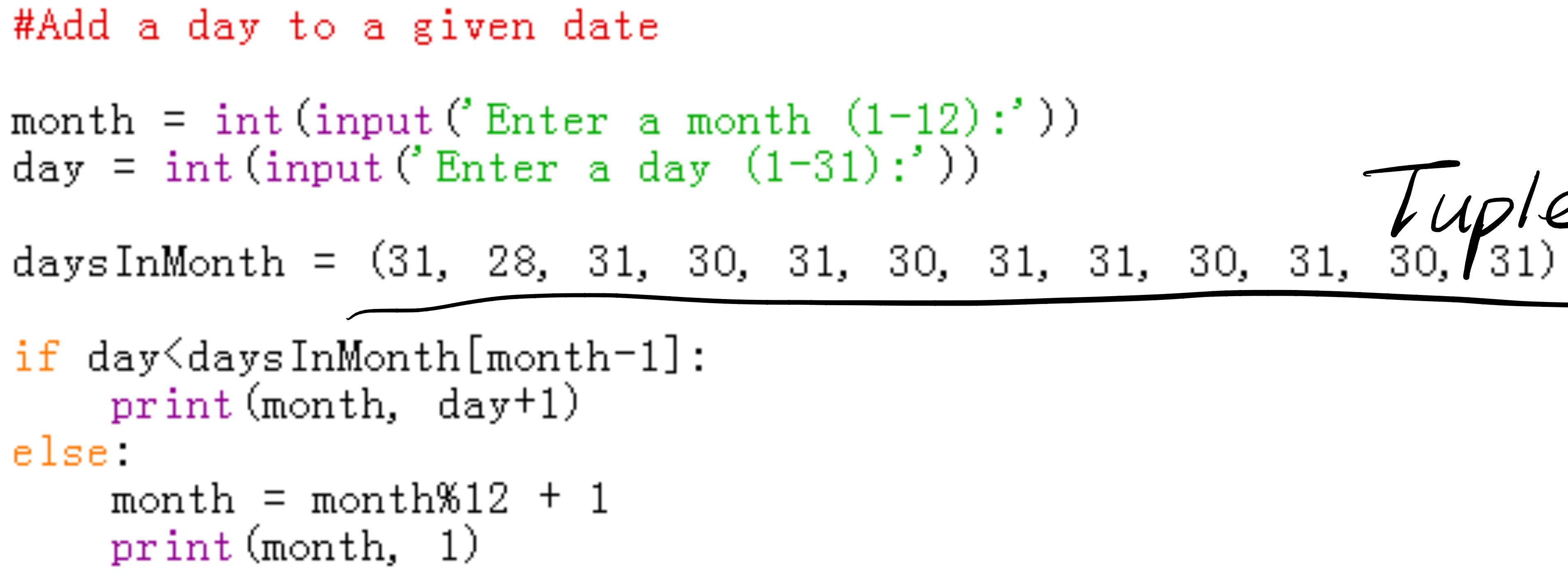
- Write a program to instruct the user to input the working hours and hourly rate, and then output the salary. If the working hours exceed 40 hours, then the extra hours received 1.5 times pay.

```
workHour = input('Enter your work hour:')
rate = input('Enter your hourly rate:')

workHour = eval(workHour)
rate = eval(rate)

if workHour<=40:
    salary = workHour*rate
else:
    salary = 40*rate+(workHour-40)*1.5

print('your salary is:', salary)
```

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



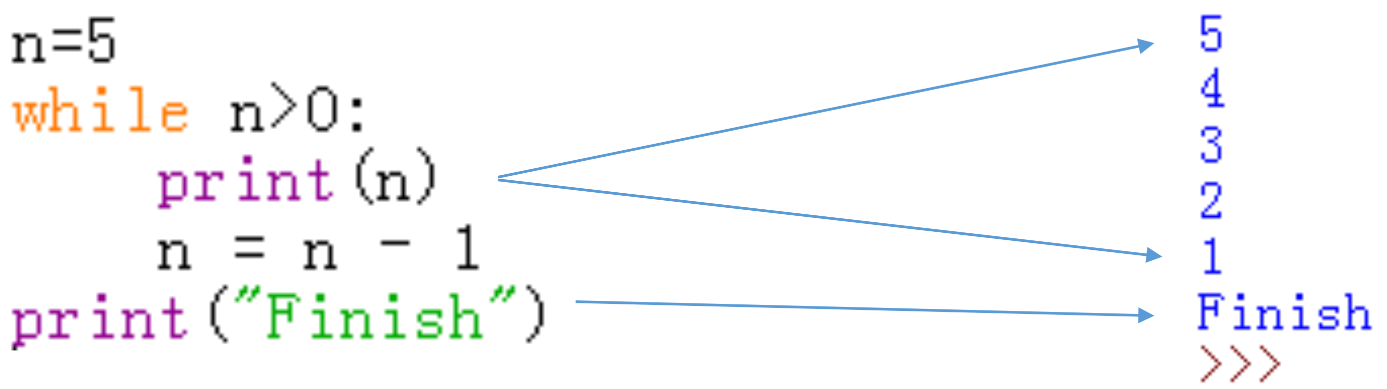
```
#Add a day to a given date

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)
```

Tuple

Repeated flow

Program

Outputs

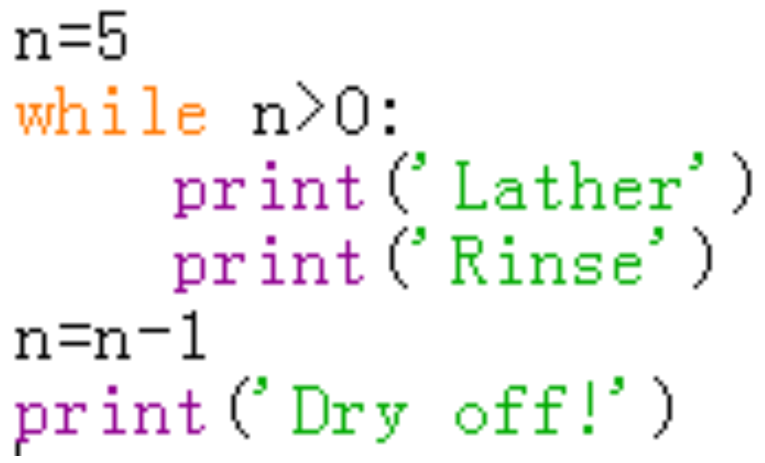


```
n=5
while n>0:
    print(n)
    n = n - 1
print("Finish")
```

```
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

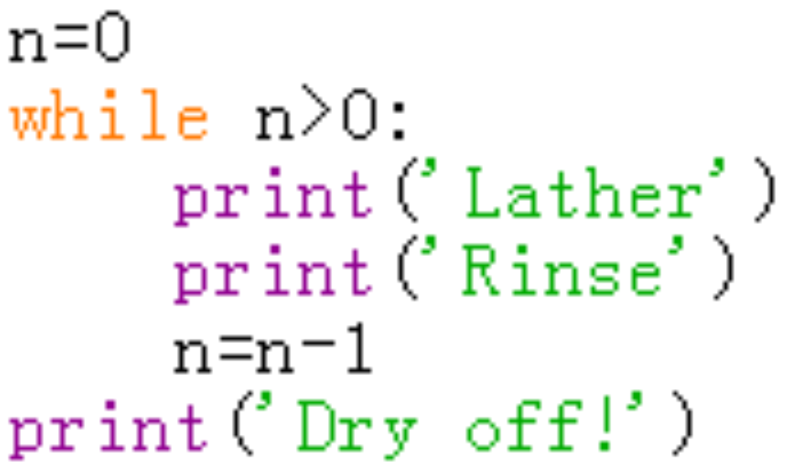
An infinite loop



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

- What is wrong with this program?

Another loop

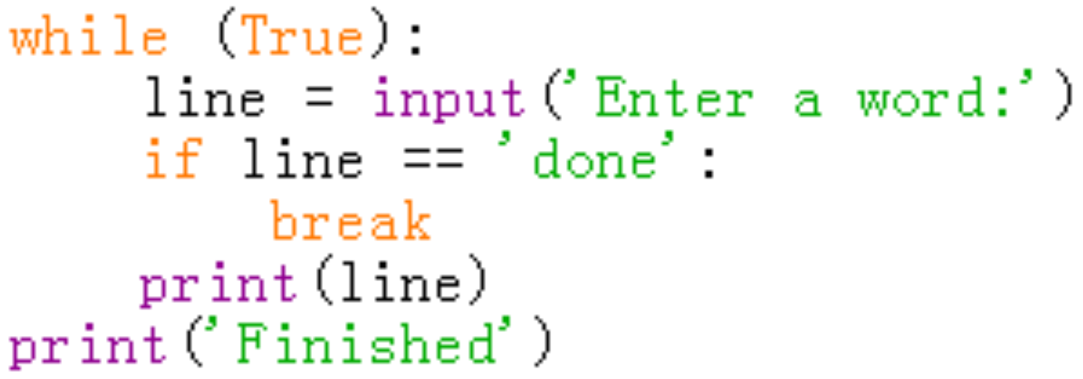


```
n=0
while n>0:
    print(’Lather’)
    print(’Rinse’)
    n=n-1
print(’Dry off!’)
```

- What is wrong with this program?

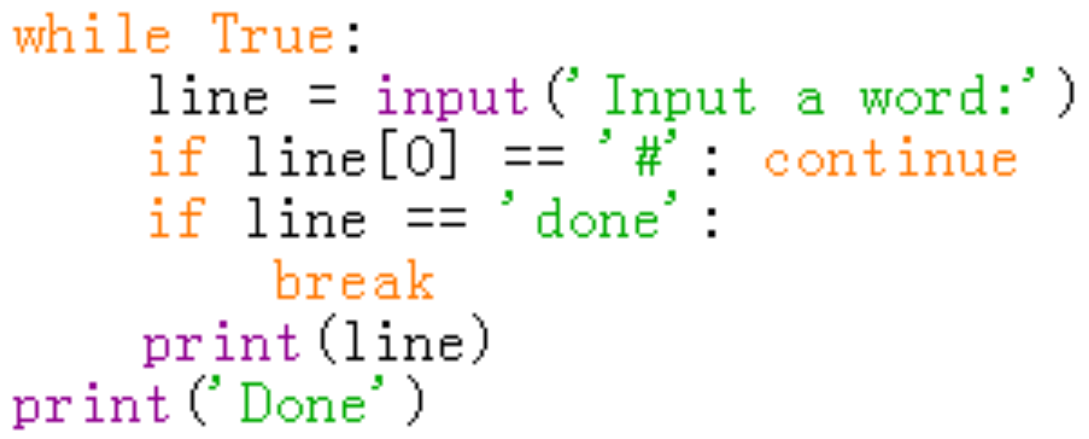
Breaking out of a loop

- 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

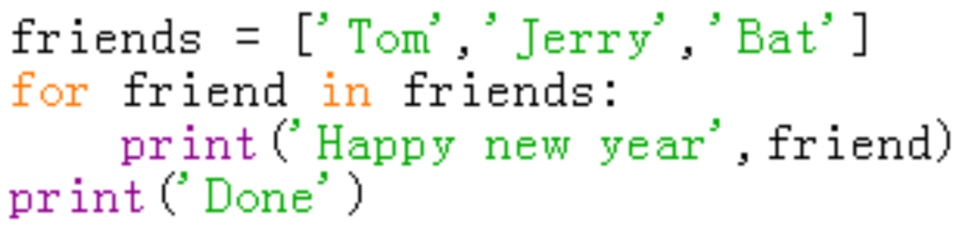
```
for i in [5,4,3,2,1]:
    print(i)
print(’Finished’)
```

Output

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

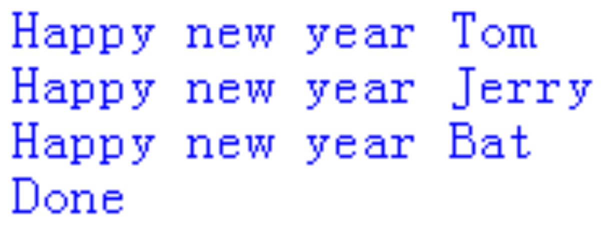
Another example

Example



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

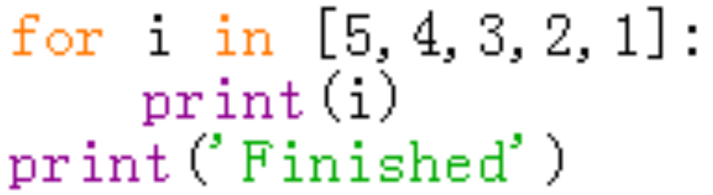
Output



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

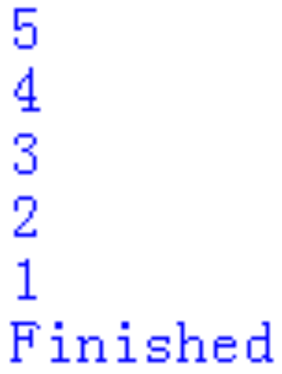
For loop

Example



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

Output

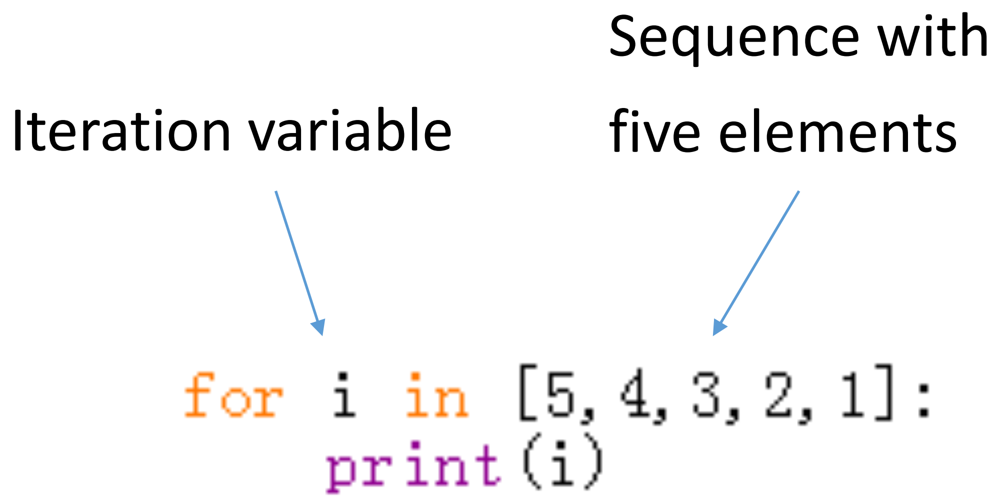


```
5
4
3
2
1
Finished
```

- 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



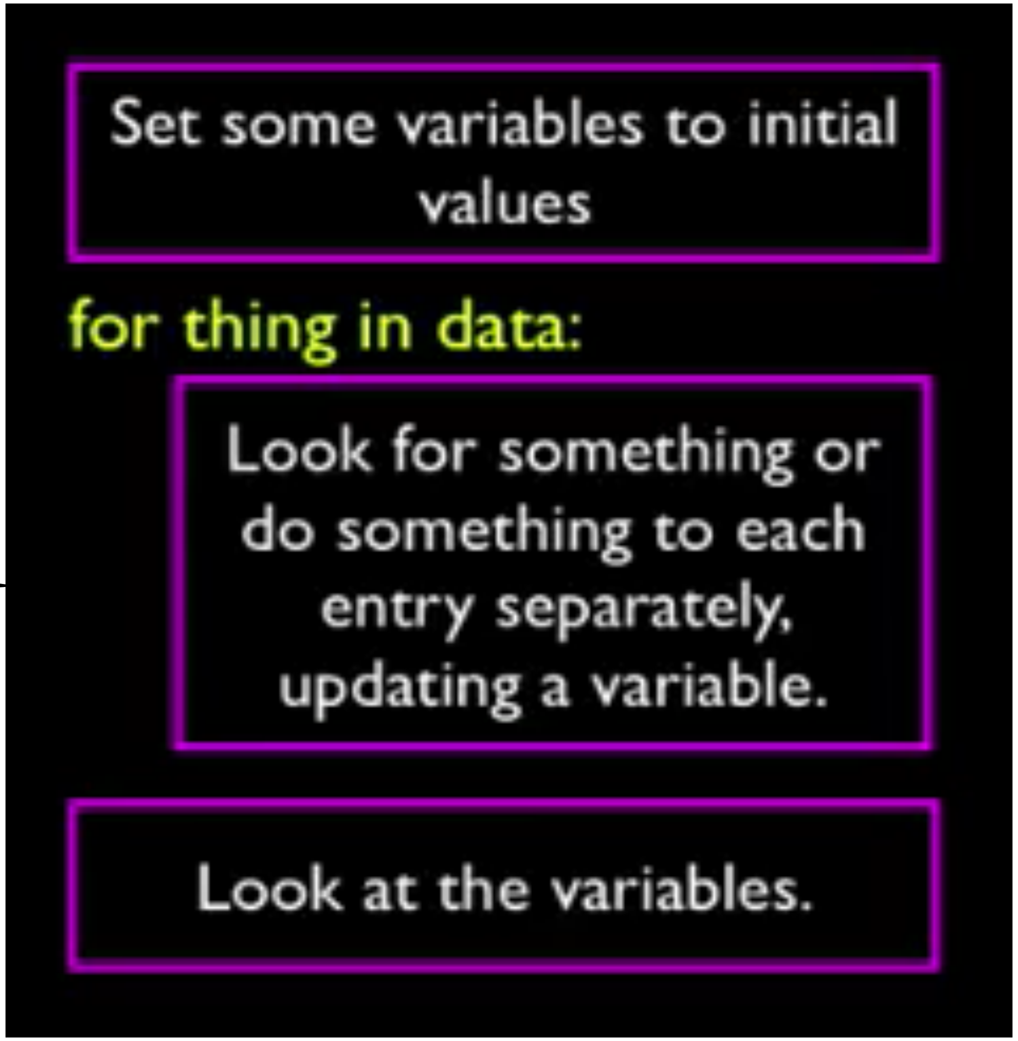
```
for i in [5, 4, 3, 2, 1]:
    print(i)
```

Loop samples

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

Making “smart” loops

step 1: Initialization
Step 2: for i in data:
    do sth. on i
    update variable
Step 3: output
    check value of



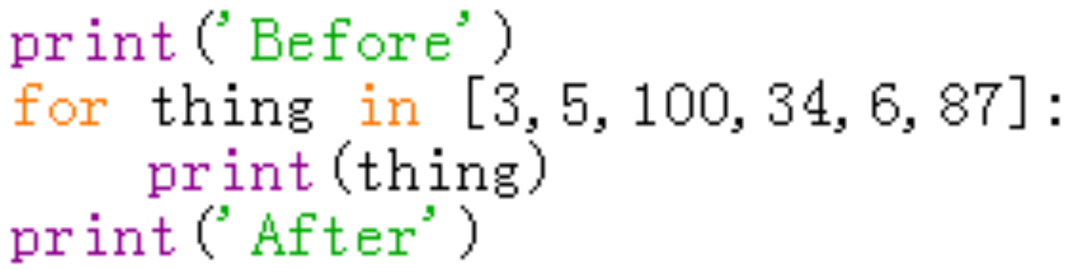
Set some variables to initial values

```
for thing in data:
    Look for something or do something to each entry separately, updating a variable.
```

Look at the variables.

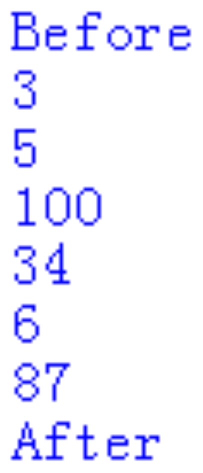
Looping through a set

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

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

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

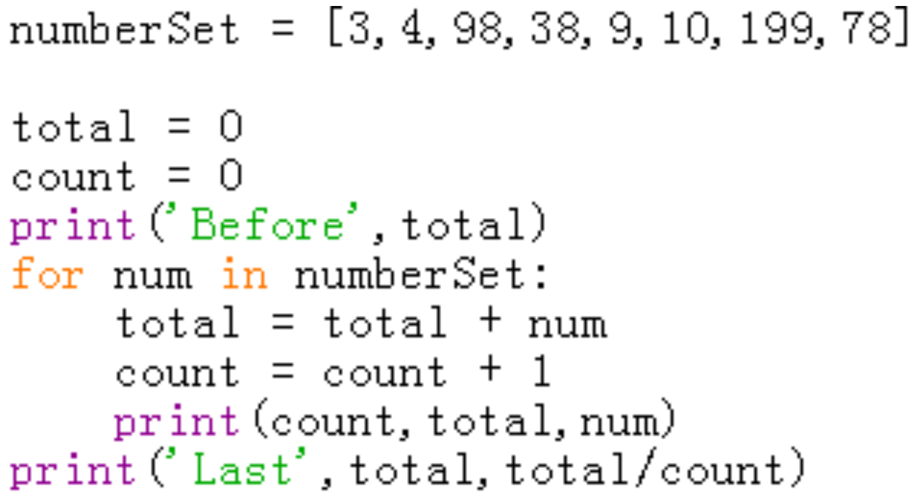
```
numberSet = [3, 4, 98, 38, 9, 10, 199, 78]

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
```

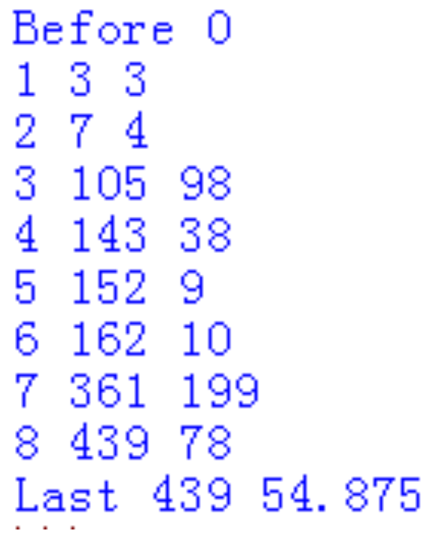
Practice

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

Answer



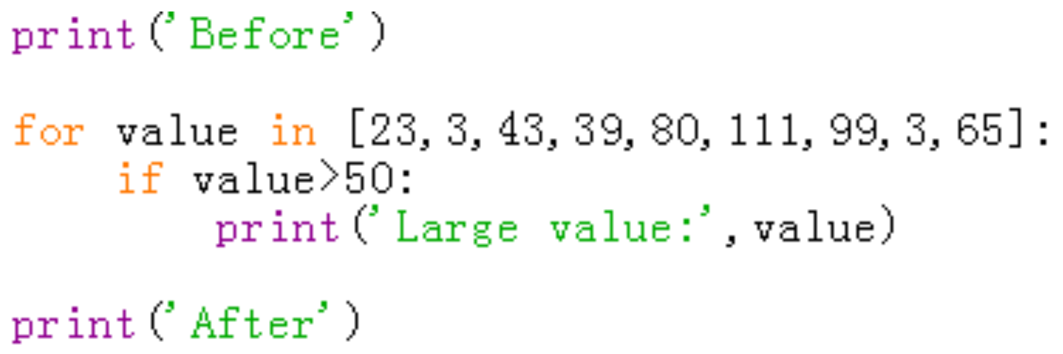
```python
numberSet = [3, 4, 98, 38, 9, 10, 199, 78]

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
```

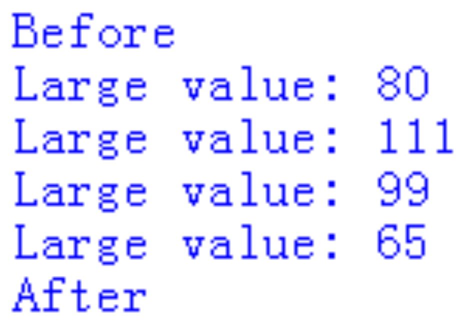
Filtering in a loop

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)
```

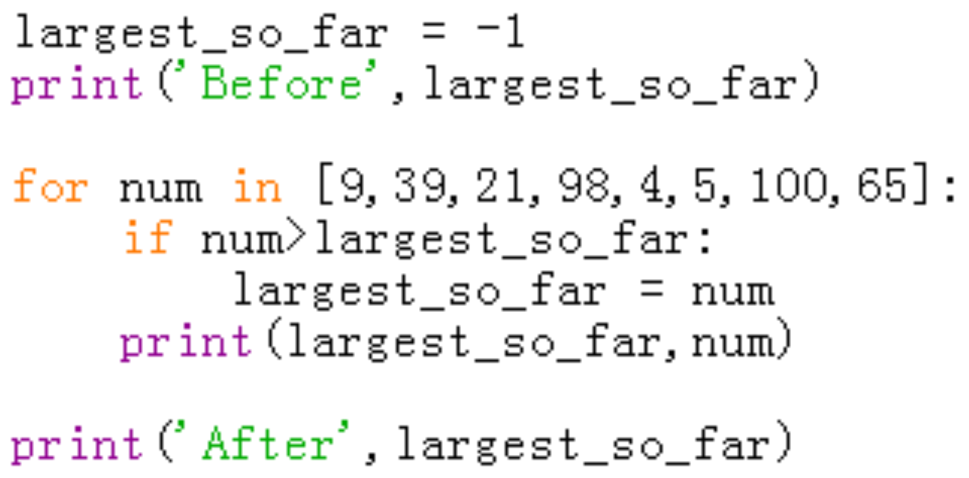
Output

```
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

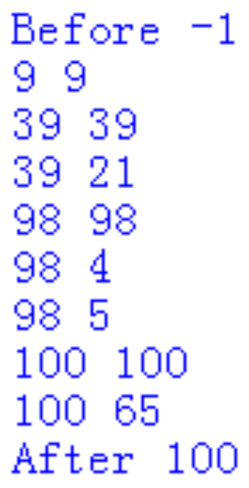
Finding the largest number

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)
```

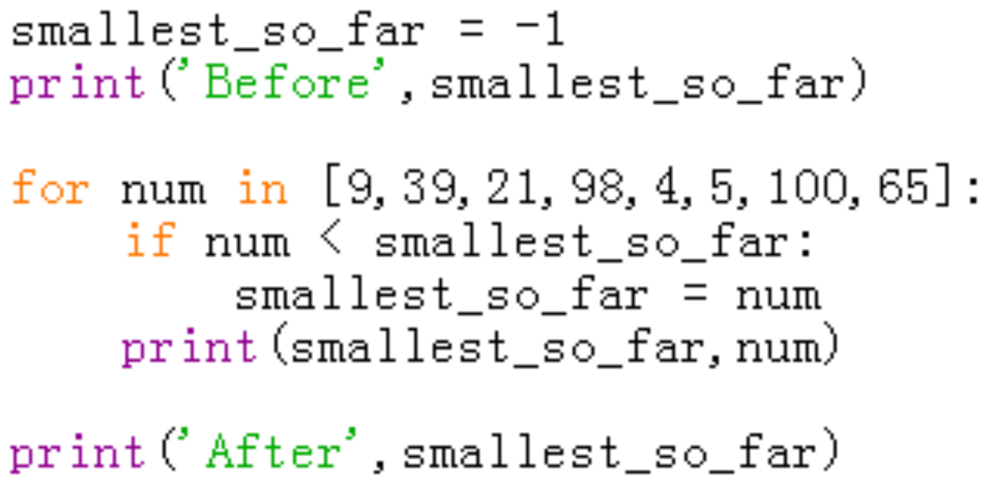
Output



```
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

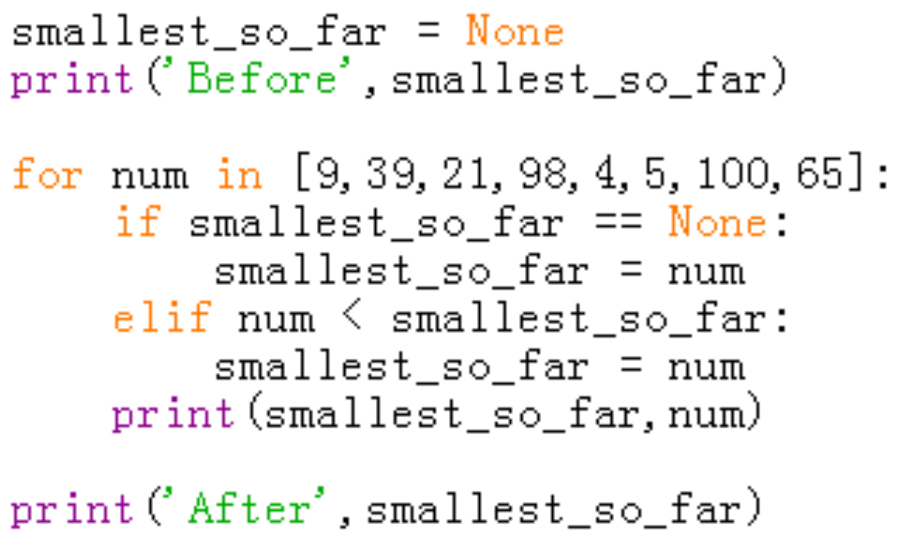


```
smallest_so_far = -1
print(’Before’,smallest_so_far)

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?

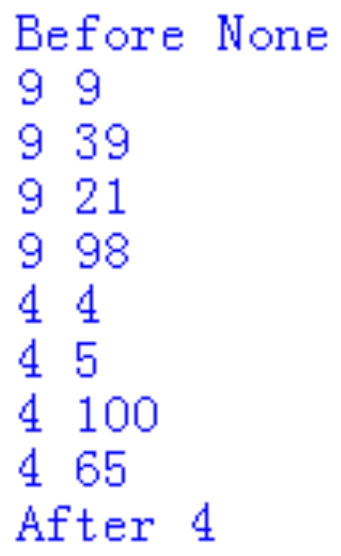
Finding the smallest number

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)
```

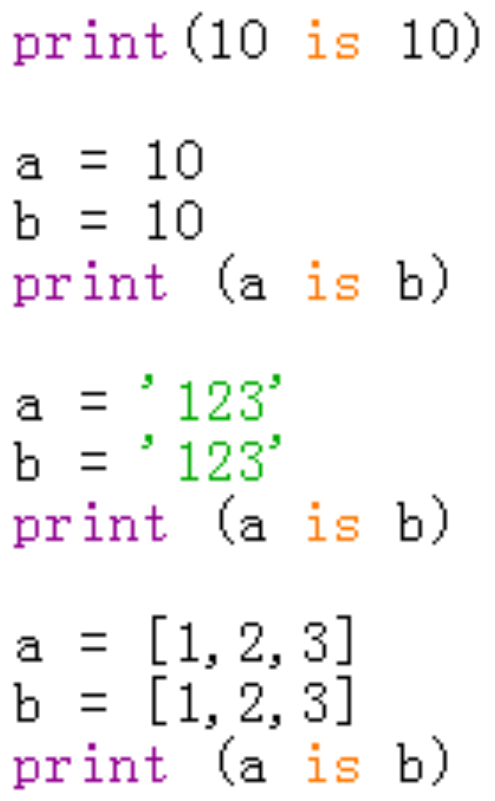
- Python has a "is" operator which can be used in logical expression
- Implies "is the same as"
- Similar to, but stronger than ==
- "is not" is also an operator

== / != ⇒ Value

is / isnot ⇒ Address

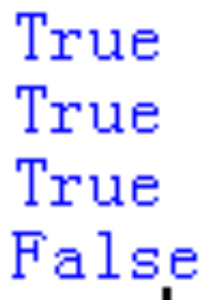
Is operator

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
```