15-110 Principles of Computing – S19

Lecture 5:
String operations, Boolean types, Conditionals

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Strings so far

- **String instantiation**

```
greet_joe = "Hello Joe"
greet_mary = 'Hello Mary'
greet_bob = '''Hello Bob'''
greet_eve = """Hello Eve"""
greet_all = '''Hello Joe and Mary and
               Bob and Eve'''
```

- **String concatenation**, + overloaded operator

```
greet_joe = "Hello Joe"
greet_mary = "hello Mary"
print(greet_joe + ", " + greet_mary)
print (greet_joe + 2)
```

- **String duplication**, * overloaded operator

```
zero_bit = "0"
one_bit = '1'
binary_256 = one_bit + (8 * zero_bit)
print("256 in binary format is", binary_256, binary_256 * (-4))
```

- **Indexing**:

```
greet="Hello Joe"
print(greet[0], greet[4])
print(greet[-4])
```

H	e	l	l	o		J	o	e
0	1	2	3	4	5	6	7	8

H	e	l	l	o		J	o	e
-9	-8	-7	-6	-5	-4	-3	-2	-1

String operators: Membership

- **Part of,** `in` operator, *overloaded:* Membership operator that returns `True` if the first operand is contained within the second, and `False` otherwise

```
s = “Joe”
in_hello = s in “Hello Joe”
in_food = s in “Yummy meal”
print(in_hello, in_food, type(in_hello))
```

```
True False <class 'bool'>
```

- **Not Part of,** `not in` operator, *overloaded:* Membership operator that returns `True` if the first operand is not contained within the second, and `False` otherwise

```
s = “Joe”
in_hello = s not in “Hello Joe”
in_food = s not in “Yummy meal”
print(in_hello, in_food, type(in_hello))
```

```
False True <class 'bool'>
```

Built-in String functions: Length and Casting

- **`len()`** function*:* Returns the <u>length of a string</u>

```
s = "Joe and Mary"
length = len(s)
print(s, length)
```

```
Joe and Mary  12
```

- **`str(o)`** function*: Virtually any object* `obj` *in Python can be rendered as a string*. Therefore, `str(obj)` returns the string representation of a python object `obj`:

```
n = 150.5
s = str(n)
print(s)
```

```
150.5
```

Built-in String functions: Integer code of a character

- **`ord(c)`** function*:* Takes a character `c` and returns the *Unicode* UTF-8 code

```
n1 = ord('a')
n2 = ord('€')
print(n1, n2)
```

```
97   8364
```

- **`chr(n)`** function*:* It does the opposite, it returns a character value for the given integer `n` representing a UTF-8 code (1,114,112 is the max number of code points available in UTF-8)

```
s1 = chr(97)
s2 = chr(8364)
print(s1, s2)
```

```
a €
```

Immutability/Mutability and Identity of an object

- Strings are **immutable** object types: <u>we can't change the value of a string literal / variable!</u>
  - Once created, the string keeps its value for its entire lifetime

```
s = "abcd"
print( s[0]+s[3])
s[3] = 'z'
```

```
ad
TypeError: 'str' object does not support item assignment
```

- We can "change" the value of a string variable by *reassigning* its value, which amounts to create a <u>new string variable</u>

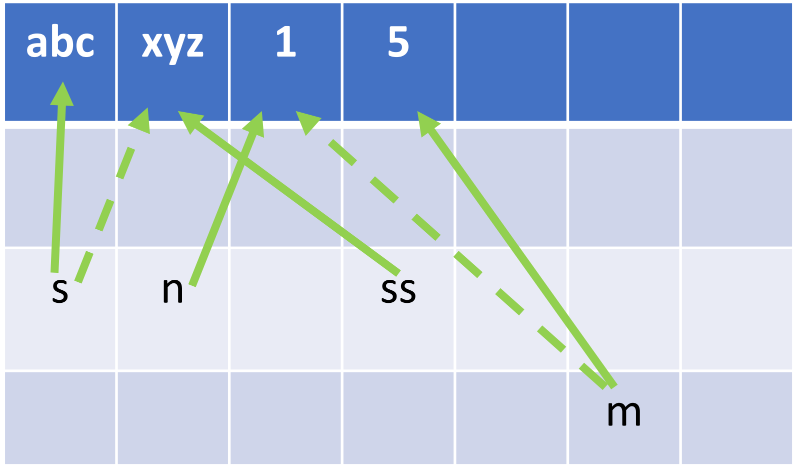
```
s = "abcd"
print( s[0]+s[3])
s = "abcz"
print(s)
```

```
ad
abcz
```

- This clearly <u>holds for all scalar object types</u>, which all are *immutable* (a change in the value corresponds into a new variable, possibly a new memory location)

Immutability/Mutability and Identity of an object

- **`id(obj)`** function*:* Takes an object `obj` as an input and returns its **identity**, an integer number that is <u>unique for the object</u> during its lifetime in the program
  - For an *immutable* object type, you can think of the identity as the <u>address in memory</u> of the literal(s) that give the *value of the object*
  - For a *mutable* object type, you can think of the identity as the address in memory of the variable




```
s = “abc”
ss = “xyz”
n = 1
m = 5
print( id(s), id(ss), id(n), id(m))
```

```
4652072720  4327641640  4307354688  4307354816
```

```
s = “xyz”
ss = “xyz”
n = 1
m = n
print( id(s), id(ss), id(n), id(m), id(1), id(“abcd”))
```

```
4652072720  4652072720  4307354688  4307354688
4307354688 4652072720
```

String slicing

- **Extracting substrings from a string**, known as string slicing. If `s` is a string, an expression of the form `s[m:n]` returns the portion of `s` starting with position `m`, and up to but not including position `n`

```
s = "Hello Joe"
ss = s[0:4]
print(ss)
```

```
Hell
```

- Slicing into empty strings
  - s[4:2] returns the empty string
  - s[2:2] returns the empty string

- Why isn't the character at position `n` not included?
  - The result is a string of `m–n` characters

- Slicing with negative indices
  - s[0:4] and s[-9:-5] return the same substring

- Shortcuts: omitting indices produces some default behavior
  - s[:4] is equivalent to s[0:4]
  - s[2:9] is equivalent to s[2:] and to s[2:len(s)]
  - s[:] is equivalent to s (it's precisely the same object in memory, same id)

- Slicing can be used to modify a string, by **creating a new variable** including the desired changes:
  - s_new = s[0:5] + '! ' + s[6:] + ' and Mary'

String slicing with a stride

- **Extracting substrings of non (necessarily) adjacent characters from a string**, known as slicing with a stride: If `s` is a string, an expression of the form `s[m:n:s]` returns the portion of `s` starting with position `m`, and up to but not including position `n`, with the third index `s` designating a stride (a step), which indicates how many characters to jump after retrieving each next character in the slice

```
s = “Hello Joe”
ss = s[0:9:2]
print(ss)
```

```
HloJe
```

Slice 0:9:2 starts with the first character and ends with the last character (the whole string), and every second character is skipped

- Indices can be omitted: first and second indices default to the first and last characters respectively, while the third defaults to 1
  - s[::4] is equivalent to s[0:9:4]
  - s[:6:2] is equivalent to s[0:6:2]
  - s[1:6:] is equivalent to s[1:6:1]
  - s[::] is equivalent to s (it’s the same object)

- Slicing with negative indices: steps are *backward*, with the first index that must be greater than the second index
  - s[4:0:-1] gives ‘olle’
  - s[::-1] gives ’eoJ olleH’

Built-in String *Methods*

- **Functions**: callable procedures that can be invoked to perform specific tasks (can take generic arguments)
- **Method**: <u>a specialized type of callable procedure that is tightly associated with an object</u>. Like a function, a method is called to perform a precise task, but it is invoked on a specific object and has knowledge of its target object during execution → Will understand this more when study <u>class objects</u>
- **Dot notation** for invoking a method on an object:

```
obj.method_name(parameters)
```

```
s = "Hello Joe"
ss = s.lower()
print(ss)
```

```
hello joe
```

```
s = "Hello Joe"
ss = s.upper()
print(ss)
```

```
HELLO JOE
```

Let's look at the methods built-in with the string (class) type, and let `s` be a string variable

Built-in String Methods: Case Conversion

- `s.capitalize():` returns a copy of s with the first character converted to uppercase and all other characters converted to lowercase:
- `s.swapcase():` returns a copy of s with uppercase alphabetic characters converted to lowercase and vice versa. Non-alphabetic characters are unchanged.
- `s.title():` returns a copy of s in which the first letter of each word (separated by spaces) is converted to uppercase and remaining letters are lowercase
- `s.lower()`
- `s.upper()`

Built-in String Methods: Count, Find, and Replace

- `s.count(<sub>):` returns the number of non-overlapping occurrences of substring <sub> in s
  - s = “moo ooh pooh”
  - s.count(“oo”) → 3
  - “moo ooh pooh”.count(“oo”)
- `s.count(<sub>, <start>, <end>):` returns the number of non-overlapping occurrences of substring <sub> in the s slice defined by <start> and <end>
  - s = “moo ooh pooh”
  - s.count(“oo”, 3, len(s)) → 2

Built-in String Methods: Count, Find, and Replace

- `s.endswith(<suffix>):` returns True if s ends with the specified <suffix>, and False otherwise
  - s = “crazy bar”
  - s.endswith(“bar”) → True
- `s.endswith(<suffix>, <start>, <end>):` as above, but now the comparison is restricted to the substring indicated by <start> and <end>
  - s = “crazy bar”
  - s.endswith(“bar”, 0, 5) → False
- `s.startswith(<suffix>):` analogous to `endswith(),` but checking if the string begins with a given substring

Built-in String Methods: Count, Find, and Replace

- `s.find(<sub>):` returns the lowest index in s where the substring <sub> is found, -1 is returned if the substring is not found
  - s = “crazy bar bar”
  - s.find (“bar”) → 6
  - s.find(“star”) → -1
- `s.find(<suffix>, <start>, <end>):` as above, but now the search is restricted to the substring indicated by <start> and <end>
  - s = “crazy bar bar”
  - s.find(“bar”, 7, 13) → 10

Built-in String Methods: Count, Find, and Replace

- `s.rfind(<sub>):` searches s starting from the end, such that it returns the highest index in s where the substring <sub> is found, -1 is returned if the substring is not found
  - s = “crazy bar bar”
  - s.rfind (“bar”) → 10
  - s.find(“bar”) → 6
- `s.rfind(<suffix>, <start>, <end>):` as above, but now the search is restricted to the substring indicated by <start> and <end>
  - s = “crazy bar bar”
  - s.rfind(“bar”, 0, 10) → 6

Built-in String Methods: Count, Find, and Replace

- `s.replace(<old>, <new>):` returns a *copy* of s with all occurrences of substring <old> replaced by new. If there are no occurrence of <old>, the copy is identical to the original (but it's still a different object)
  - s = "one step, two steps, three steps"
  - s.replace ("step", "stop") → "one stop, two stops, three stops"
- `s.replace(<old>, <new>, <max>):` as above, but now the number of replacements is limited to the <max> value
  - s = "one step, two steps, three steps"
  - s.replace("step", "stop", 2) → "one stop, two stops, three steps"

Built-in String Methods: String formatting

- `s.center(<width>[, <fill>])`
- `s.expandtabs(tabsize=8)`
- `s.ljust(<width>[, <fill>])`
- `s.lstrip([<chars>])`
- `s.rjust(<width>[, <fill>])`
- `s.rstrip([<chars>])`
- `s.strip([<chars>])`
- `s.zfill(<width>)`

Built-in String Methods: Character classification

- `s.isalpha()`
- `s.isalnum()`
- `s.isdigit()`
- `s.isidentifier()`
- `s.islower()`
- `s.isupper()`
- `s.isprintable()`
- `s.isspace()`
- `s.istitle()`

String formatting using escape sequences

- print("He said, "What's there?"") → SyntaxError: Invalid syntax
- print(‘He said, "What's there?”’) → SyntaxError: Invalid syntax
- print(“’’He said, "What's there?”’’’) → Ok!
- Alternative way: Use of **Escape sequences**
  - An escape sequence **starts with a backslash ** such that what follows <u>is interpreted differently from usual</u>
  - print("He said, "What\\'s there?"") → Ok
  - print(‘He said, \\"What's there?\\”’) → Ok
- \\n : new line feed is inserted   print(“Hello!\\nThis goes on a new line”)
- \\t : tabular space is inserted   print(“Hello!\\t\\tThis gets two tab spaces”)
- \\\\ : this allows to write file/folder paths in windows print("C:\\\\Python64\\\\Lib")
- \\a : this rings a bell! print(“This rings a bell\\a”)

String formatting using escape sequences

Escape Sequence	Description
\newline	Backslash and newline ignored
\\	Backslash
\'	Single quote
\"	Double quote
\a	ASCII Bell
\b	ASCII Backspace
\f	ASCII Formfeed
\n	ASCII Linefeed
\r	ASCII Carriage Return
\t	ASCII Horizontal Tab
\v	ASCII Vertical Tab
\ooo	Character with octal value ooo
\xHH	Character with hexadecimal value HH

Boolean types and Comparison (Relational) operators

- `bool`: **Boolean (logical) values**
  - Instances of literals of type `bool` are: `True, False`
  - `x = True` defines a boolean variable with a true value
  - `print(x)` → `True`
- A **boolean expression** is an expression that evaluates to a boolean value, true or false
- A boolean expression results from the application of **comparison operators**
  - `x == y` *x is equal to y*
  - `x != y` *x is not equal to y*
  - `x > y` *x is greater than y*
  - `x < y` *x is less than y*
  - `x >= y` *x is greater than or equal to y*
  - `x <= y` *x is less than or equal to y*

x,y are expressions that can evaluate to numbers, strings, boolean types,…
overloaded operators

Boolean types and Comparison (Relational) operators

16 different examples using relational operators

```
n1 = 5
n2 = 7
d = n2 == n1
print(d, type(d))
```

```
n1 = 5.5
n2 = 7.1
d = n2 == n1
print(d, type(d))
```

```
n1 = 5
n2 = 7
d = n2 != n1
print(d, type(d))
```

```
n1 = 5.5
n2 = 7.1
d = n2 != n1
print(d, type(d))
```

```
s1 = ‘b’
s2 = ‘c’
d = s2 == s1
print(d, type(d))
```

```
s1 = True
s2 = False
d = s2 == s1
print(d, type(d))
```

```
s1 = ‘b’
s2 = ‘c’
d = s2 != s1
print(d, type(d))
```

```
s1 = True
s2 = False
d = s2 != s1
print(d, type(d))
```

```
n1 = 5
n2 = 7
d = n2 > n1
print(d, type(d))
```

```
n1 = 5.5
n2 = 7.1
d = n2 > n1
print(d, type(d))
```

```
n1 = 5
n2 = 7
d = n2 >= n1
print(d, type(d))
```

```
n1 = 5.5
n2 = 5.5
d = n2 >= n1
print(d, type(d))
```

```
s1 = ‘b’
s2 = ‘c’
d = s2 > s1
print(d, type(d))
```

```
s1 = True
s2 = False
d = s2 > s1
print(d, type(d))
```

```
s1 = ‘bass’
s2 = ‘class’
d = s2 >= s1
print(d, type(d))
```

```
s1 = True
s2 = False
d = s2 >= s1
print(d, type(d))
```

Boolean types and Logical operators: and

- `and`: `(x and y)` evaluates to `True` if and only if <u>both</u> `x` and `y` are `True` expressions
  - a = ((2 != 3) and (‘yes’ == ‘yes’)) → True
  - a = ((2 != 2) and (‘yes’ == ‘yes’)) → False
  - a = ((2 != 3) and (‘yes’ == ‘no’)) → False
  - a = ((2 != 2) and (‘yes’ == ‘no’)) → False
- Example of typical application: check whether a value x belongs or not to a certain interval
  - is $0 \leq x \leq 5$?

```
range = (x >= 0) and (x <=5)
```

- Example of typical application: guarantee that two conditions are both satisfied
  - is battery more than 95% and the phone is on?

```
conditions = (battery >= 0.95) and (phone == “on”)
```

Boolean types and Logical operators: and

- `and`: `(x and y)` evaluates to `True` if and only if <u>both</u> `x` and `y` are `True` expressions
  - a = ((2 != 3) and (‘yes’ == ‘yes’)) → True
  - a = ((2 != 2) and (‘yes’ == ‘yes’)) → False
  - a = ((2 != 3) and (‘yes’ == ‘no’)) → False
  - a = ((2 != 2) and (‘yes’ == ‘no’)) → False

Four cases, for all possible combinations of truth values of two operands, p and q

p	q	$p \wedge q$
T	T	T
T	F	F
F	T	F
F	F	F

Logical truth table for AND

- 0 for False
- 1 for True

A	B	A and B
0	0	0
0	1	0
1	0	0
1	1	1

AND

x = True
y = False
a = x * y
print(a, type(a)) → False <class ‘int’>
print(x*x, type(x*x)) → True <class ‘int’>
print(x*5, type(x*5)) → 5 <class ‘int’>
print(x*5.6, type(x*5.6)) → 5 <class ‘float’>

✓ *, overloaded operator (but result changes type)
✓ Logical `and` is equivalent <u>multiplication</u>

Boolean types and Logical operators: or

- `or: (x or y)` evaluates to `True` if and only if <u>either</u> `x or y` are `True` expressions
  - a = ((2 != 3) or (‘yes’ == ‘yes’)) → True
  - a = ((2 != 2) or (‘yes’ == ‘yes’)) → True
  - a = ((2 != 3) or (‘yes’ == ‘no’)) → True
  - a = ((2 != 2) or (‘yes’ == ‘no’)) → False

p	q	p∨q
T	T	T
T	F	T
F	T	T
F	F	F

Logical truth table for OR

A	B	A or B
0	0	0
0	1	1
1	0	1
1	1	1

OR

- is color either blue or red? check if the remainder of x, is 2 or 3 … as long as <u>one condition is satisfied</u>, the expression evaluates to True
- x equal to 5,6, or 7:

```
(x == 5) or (x == 6) or (x == 7)
```

✓ +, overloaded operator (but result changes type)
✓ Logical `or` is equivalent to <u>addition</u>

x = True
y = False
a = x + y
print(a, type(a)) → True <class ‘int’>
print(y+y, type(y+y)) → False <class ‘int’>
print(x+5, type(x+5) → 6 <class ‘int’>
print(y*5.6, type(y*5.6) → 0.0 <class ‘float’>

Boolean types and Logical operators: not

- `not`: `(not x)` evaluates to `True` if and only if `x` is a `False` expression
  - a = not (2 != 3) → True
  - a = not (‘yes’ == ‘yes’) → False

- Useful anytime the negation of an expression is needed

p	~p
T	F
F	T

A	not A
0	1
1	0

NOT

Logical truth table for NOT

x = True
y = False
print(1-x, type(1-x)) → False <class ‘int’>
print(1-y, type(1-y)) → True <class ‘int’>

✓ –, overloaded operator (but result changes type)
✓ Logical `not` is equivalent to one’s complement

Precedence rules among operators

Level	Category	Operators
7(high)	exponent	**
6	multiplication	*,/,//,%
5	addition	+,-
4	relational	==,!=,<=,>=,>,<
3	logical	not
2	logical	and
1(low)	logical	or

```
x*5 >= 10 and y-6 <= 20
```

First the arithmetic (`x*5`), then the relations (`x*5 > 5`, `y-6 <= 20`), and finally the logical `and`

Flow control with conditional execution (branching)

1. Start with an arbitrary guess value, g

2. **If** $g \cdot g$ is close enough to x (with a given numeric approximation)

   Then `Stop`, and say that g is the `answer`

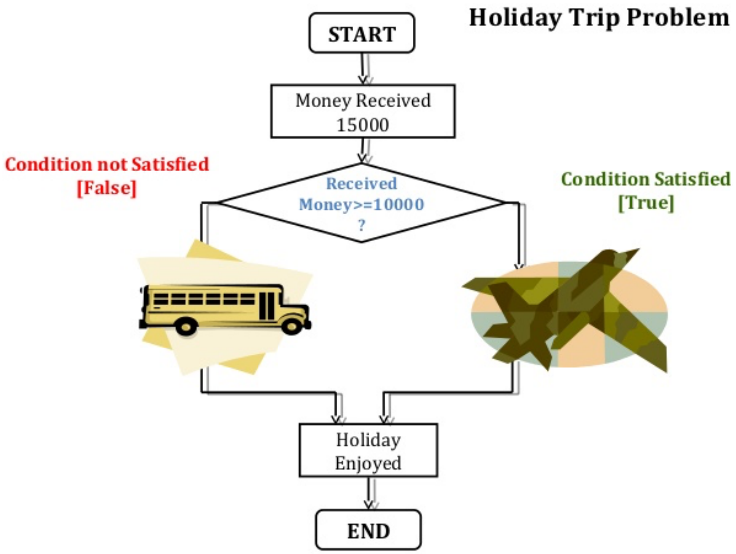
3. **Otherwise** create a new guess value by averaging g and x/g:

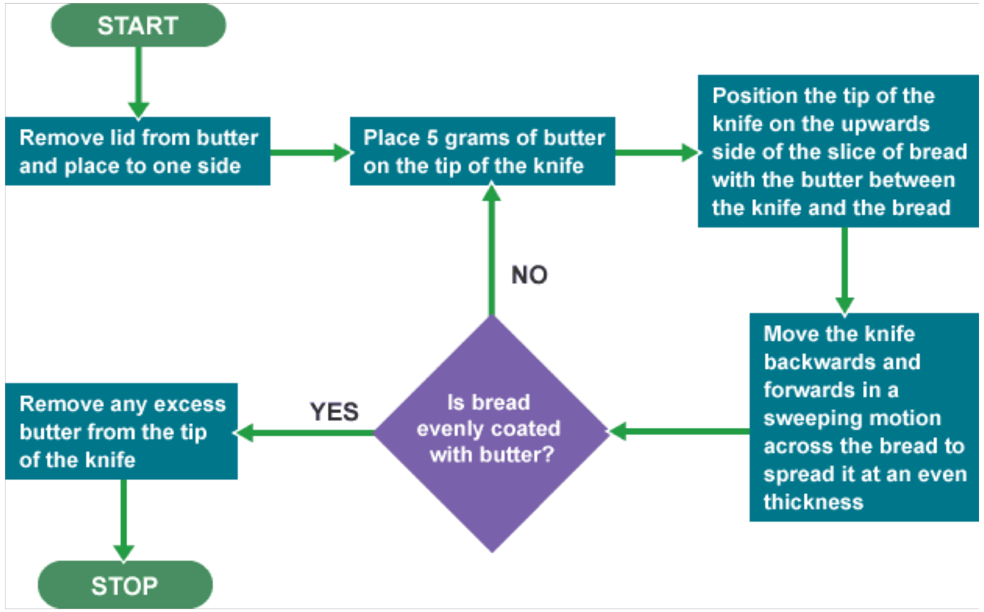
$$g = \frac{(g + x/g)}{2}$$

4. **Repeat** the steps 2 and 3 until $g \cdot g$ is close enough to x

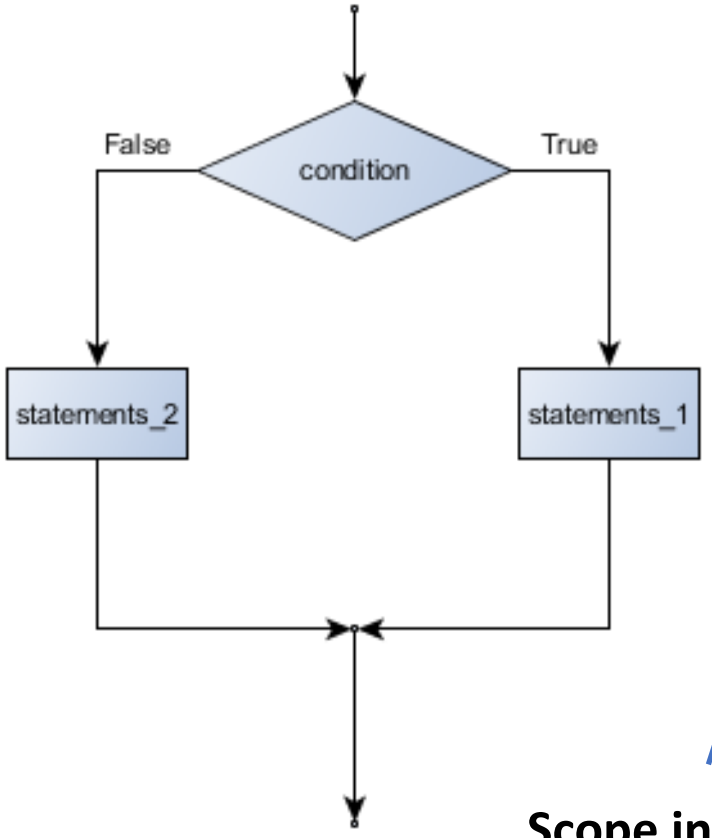
State of the program + input data

Branching …





Flow control with conditional execution: if-else



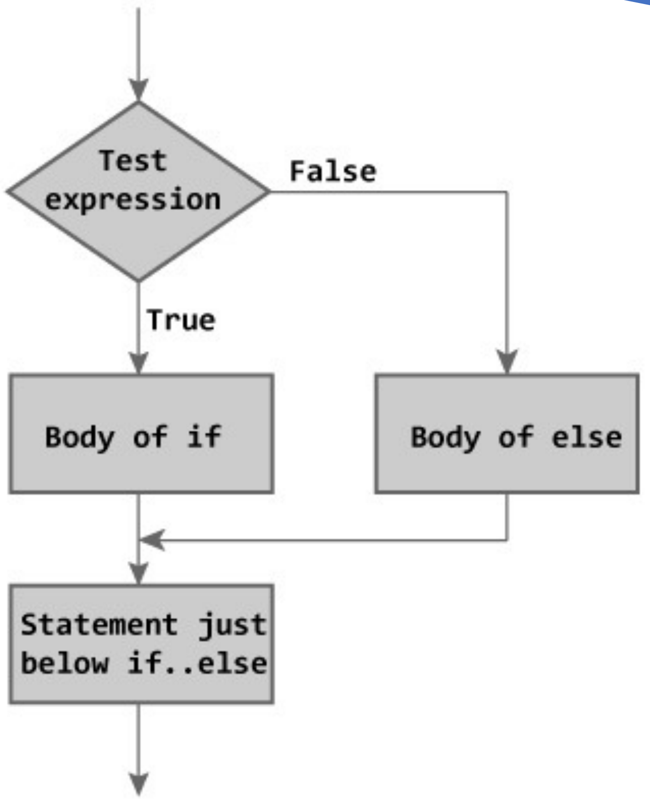

```
if boolean_expression_is_true:
    do_something
else:
    do_something_else
keep_going_on_with_the_program
```

colons

if-else keywords

Scope indentation

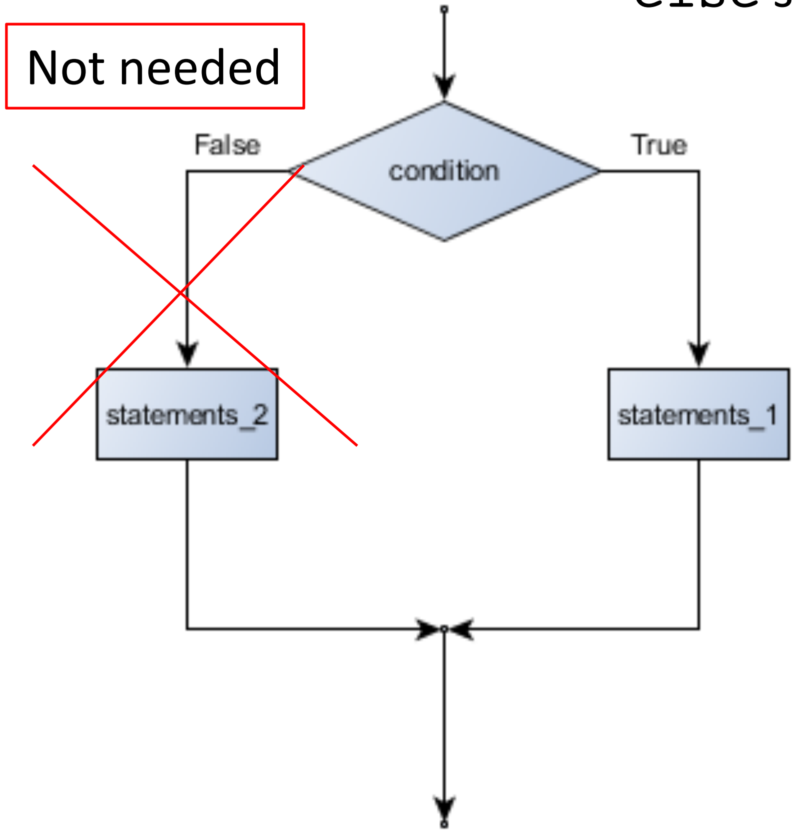
Use TABS!




```
if a > b:
    print(a)
else:
    print(b)
x = “whatever next”
print(x)
```

Flow control with conditional execution: if

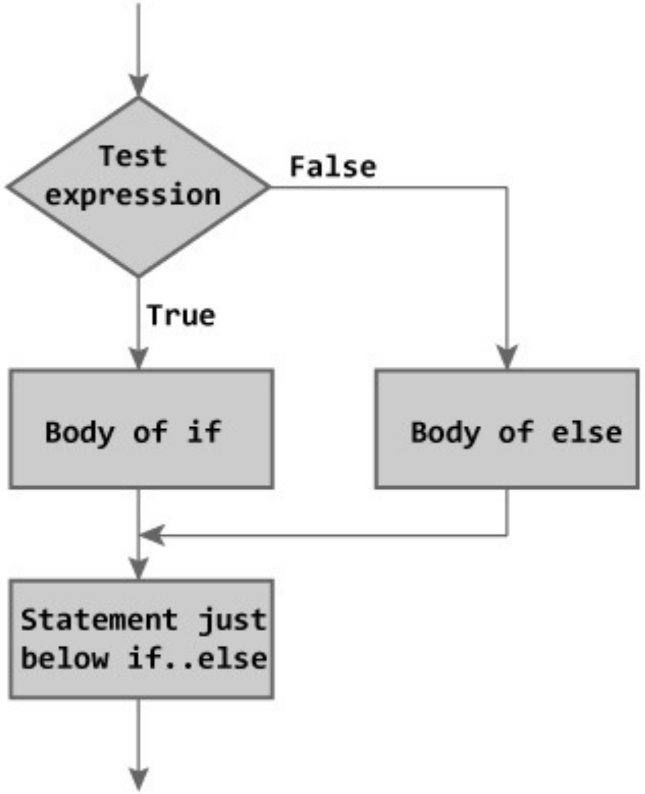
- Sometimes we only have one condition to check, one branch in the program flow
- `else` statement is *not* required




```
if boolean_expression_is_true:
    do_something
keep_going_on_with the program
```

```
if a > b:
    print(a)
x = “whatever next”
print(x)
```

Flow control with conditional execution: scoping



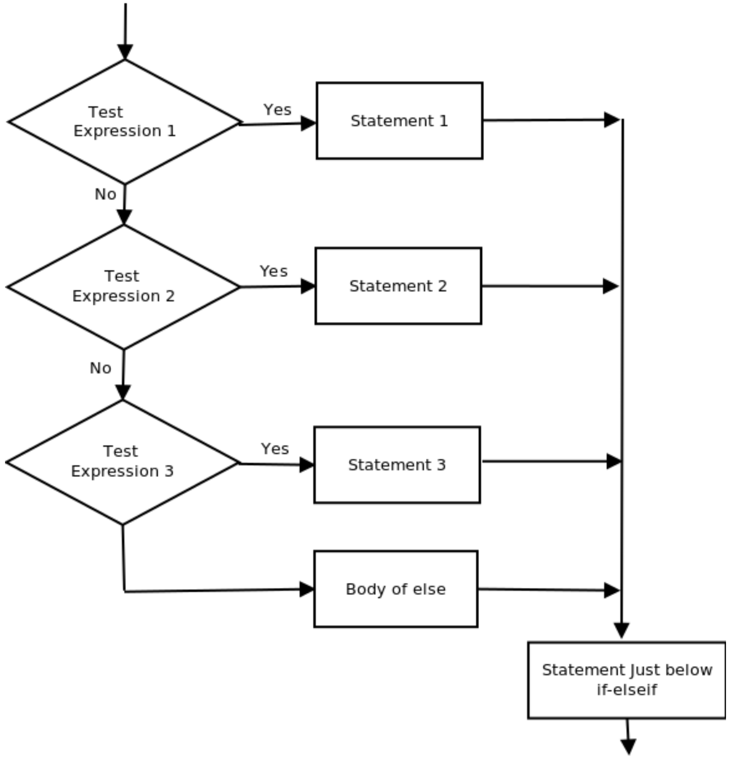

```
if boolean_expression_is_true:
    do_something
else:
    do_something_else
keep_going_on_with the program
```

Local scopes

```
if a > b:
    y = 3
    print(a)
else:
    print(b, y)
x = "whatever next"
print(x, y)
```

It may be not defined

Flow control with conditional execution: if-elif-else




```
if boolean_expression_1_is_true:
    do_something_1
elif: boolean_expression_2_is_true:
    do_something_2
elif: boolean_expression_3_is_true:
    do_something_3
…..
else:
    do_something_else
keep_going_on_with the program
```

- Also in this case, the `else` part is optional

```
if a > b:
    print(a)
elif a == b:
    a = a + 1
elif a == b - 1:
    print(b)
x = "whatever next"
```

```
if a > b:
    print(a)
elif a == b:
    a = a + 1
elif a === b - 1:
    print(b)
else:
    print(a + b)
x = "whatever next"
print(x)
```