3. Conditional Execution

Topics:

- Boolean values
- Relational operators
- `if` statements
- The Boolean type

Motivation

Problem:

Assign positive float values to variables `a` and `b` and print the values `a**b` and `b**a`.

Solution:

```
a = input('Enter a pos float: ')
b = input('Enter a pos float: ')
print a**b, b**a
```

Motivation

Problem:

Assign float values to variables `a` and `b` and print just the larger of `a**b` and `b**a`

Solution:

?

7**2 < 2**7 2**3 < 3**2

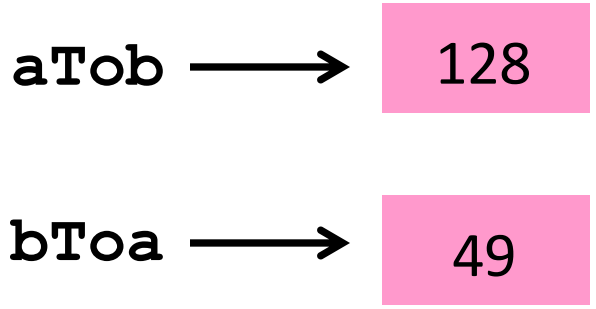
Solution Using If-Else

```
a  = input('Enter a pos float: ')
b  = input('Enter a pos float: ')
aTob = a**b
bToa = b**a
if aTob > bToa:
    print aTob
else:
    print bToa
```

This is what is called "conditional execution."

If-Else: How Does it Work?

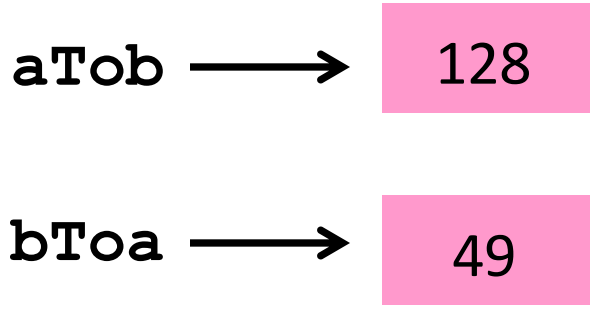
```
aTob = a**b
bToa = b**a
if aTob > bToa:
    print aTob
else:
    print bToa
```



Let's suppose the value of `a` is 2 and the value of `b` is 7.

Solution Using If-Else

```
aTob = a**b
bToa = b**a
if aTob > bToa:
    print aTob
else:
    print bToa
```



The comparison

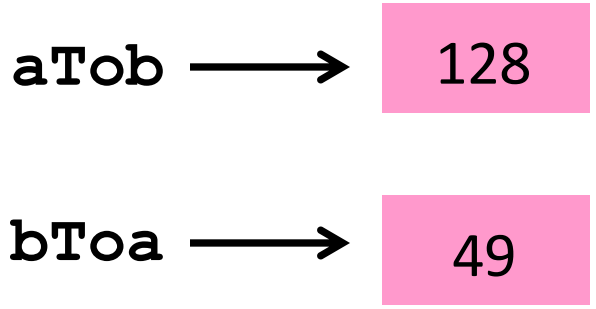
`aTob > bToa`

is called a boolean expression.
It is either True or False

Is the value of `aTob` larger than the value of `bToa` ?

Solution Using If-Else

```
aTob = a**b
bToa = b**a
if aTob > bToa:
    print aTob
else:
    print bToa
```



The boolean expression

`aTob > bToa`

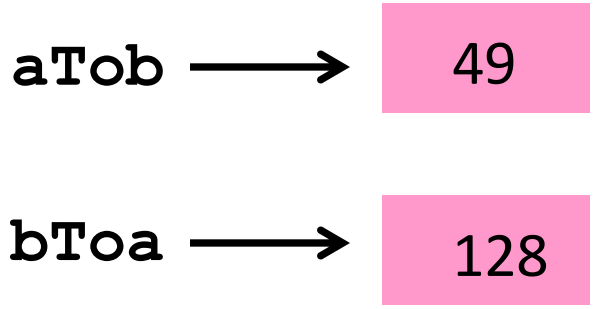
is `True` so execute

`print aTob`

Is the value of `aTob` larger than the value of `bToa` ? Yes!

If-Else: How Does it Work?

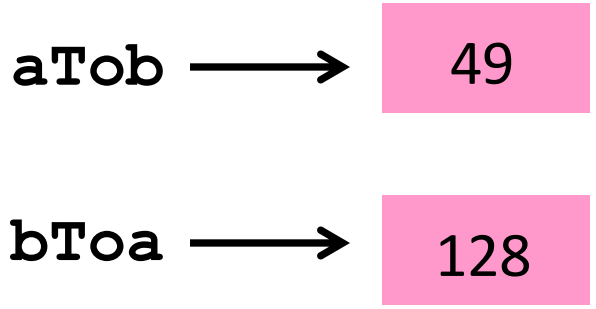
```
aTob = a**b
bToa = b**a
if aTob > bToa:
    print aTob
else:
    print bToa
```



Now let's suppose the value of `a` is 7 and the value of `b` is 2.

If-Else: How Does it Work?

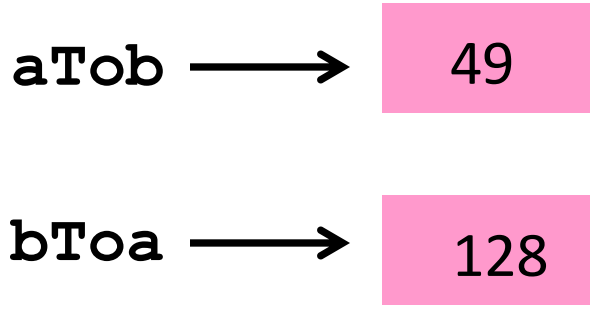
```
aTob = a**b
bToa = b**a
if aTob > bToa:
    print aTob
else:
    print bToa
```



Is the value of `aTob` larger than the value of `bToa` ?

If-Else: How Does it Work?

```
aTob = a**b
bToa = b**a
if aTob > bToa:
    print aTob
else:
    print bToa
```



The boolean expression

`aTob > bToa`

is `False` so execute

`print bToa`

Is the value of `aTob` larger than the value of `bToa` ? No!

If-Else: How Does it Work?

```
aTob = a**b
bToa = b**a
if aTob > bToa:
    print aTob
else:
    print bToa
```

Note the punctuation and the indentation.

This is essential syntax.

Forgetting the colons is a major boo boo!

"Synonym"

```
aTob = a**b
bToa = b**a
if aTob > bToa:
    print aTob
else:
    print bToa
```

```
if a**b > b**a:
    print a**b
else:
    print b**a
```

In a comparison, we can have general expressions on either side of the "<".

The `if-else` Construction

```
if Boolean expression :
    Statements to execute if the
        expression if True
else:
    Statements to execute if the
        expression if False
```

This is an example of conditional execution.
The if-else construction is sometimes called "alternative execution"

The if-else Construction

```
if   a**b > b**a :
     z = b**a
else:
     z = a**b

print 'The smaller value is:',z
```

The blue box decides whether the green box or the pink box is executed.

After that choice is processed, this print is carried out.

Reminder that Indentation Is Important

```
if x%2==0:
    y = x/2
    print y
else:
    y = (x+1)/2
    print y
```

```
if x%2==0:
    y = x/2
    print y
else:
    y = (x+1)/2
print y
```

If x is even, then the code on the left will print x/2 while the code on the right will print x/2 twice (on separate lines).

Another Example

Problem:

The last character in a string 5-character string is 'y'.

Change the 'y' to 'i' and add 'es'

Solution:

```
s = s[0:4] + 'ies'
```

Want: 'carry' to become 'carries'
Use string slicing and concatenation: 'carr' + 'ies'

A Modified Problem

If the last character in a 5-character string `s` is '`y`', then

1. change the '`y`' to '`i`'
2. add '`es`'
3. assign the result to a variable `plural`.

Otherwise, just add '`s`' and assign the result to a variable `plural`.

This will require the if-else construction.

Solution

```
if s[4]==‘y’:
    plural = s[0:4] + ’ies’
else:
    plural = s + ‘s’
print s,plural
```

Remember: s[0:4] names the substring comprised of the first 4 characters.

Discussion of Solution

```
if s[4]=='y':
    plural = s[0:4] + 'ies'
else:
    plural = s + 's'
print s,plural
```

A new comparison is being used.

If you want to check to see if two expressions have the same value, use `==` .

Why? If you say `s[4]='y'` it looks like an assignment.

Discussion of Solution

```
if s[4]=='y':
    plural = s[0:4] + 'ies'
else:
    plural = s + 's'
print s,plural
```

The print statement is executed after the if-else is processed. E.g.

```
carry  carries
```

Relational Operators

<	Less than
>	Greater than
<=	Less than or equal to
>=	Greater than or equal to
==	Equal to
!=	Not equal to

Relational Operators in Action

x ---> 3 y ---> 6

```
   x < y        True
 2*x > y        False
   x <= y       True
   x >= y       False
   x == y/2     True
   x != y/2.    False
```

If the expression on the left is a different numerical type
then the expression on the right, everything is converted to float.

Boolean Operations with Strings

Are two strings equal?

```
>>> s = 'abc'
>>> s =='abc'
True
>>> s == 'abc '
False
```

Two strings are equal if they have the same length and agree in each position.

Boolean Operations with Strings

Alphabetical order?

```
>>> s = 'Dog'
>>> s >'Horse'
False
>>> s < 'Horse'
True
>>> s < 'dog'
True
```

Alphabetical order. If `s < t` is true then `s` comes before `t` in the "extended dictionary" based on this ordering of characters:
'0123456789ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz'

Relational Operators in Action

`x --->` ‘key’ `y --->` ‘hockey’

```
        x < y          False
        x > y          True
'hoc'+x <= y           True
        x >= y         True
        x == y[3:]     True
        x != x+' '     True
```

Comparisons based on alphabetical order.
`x<y` is false because ‘key’ does not come before ‘hockey’ in the dictionary.

Another Problem

Assume that `s1` and `s2` are initialized strings.

Write code that prints them in alphabetical order on separate lines.

Solution

```
if s1<s2:
    print s1
    print s2
else:
    print s2
    print s1
```

s1 ---> ‘cat’

s2 ---> ‘dog’

s1 < s2

Is this True or False?

Solution

```
if s1<s2:
    print s1
    print s2
else:
    print s2
    print s1
```

s1 ---> ‘cat’

s2 ---> ‘dog’

It’s true!

Output:

```
cat
dog
```

Solution

```
if s1<s2:
    print s1
    print s2
else:
    print s2
    print s1
```

s1 ---> 'dog'

s2 ---> 'cat'

s1 < s2

Is this True or False?

Solution

```
if s1<s2:
    print s1
    print s2
else:
    print s2
    print s1
```

s1 ---> 'dog'

s2 ---> 'cat'

It's false!

Output:

```
cat
dog
```

Indentation Is Important

```
if s1<s2:
    print s1
    print s2
else:
    print s2
print s1
```

s1 ---> 'cat'

s2 ---> 'dog'

Output:

```
cat
dog
cat
```

What if You Have More than Two Alternatives?

For example, given a numerical test score between 0 and 100, print out the letter grade equivalent according to these rules:

A	90-100
B	80-89
C	70-79
U	<70

The If-Elif-Else Construction

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

Read "elif" as "else if"

The If-Elif-Else Construction

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

Note the punctuation and the indentation.

Read "elif" as "else if"

If-Elif-Else: How it Works

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

x ---> 75

1. Is this true?
2. No.
3. Proceed to the next comparison.

If-Elif-Else: How it Works

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

x ---> 75

1. Is this true?
2. No.
3. Proceed to the next comparison.

If-Elif-Else: How it Works

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

x ---> 75

1. Is this true?
2. Yes.
3. Execute the statement(s) it guards and proceed to whatever follows the if-elif-else

The indentation scheme "tells" Python what comes after the if-elif-else

If-Elif-Else: How it Works

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

x ---> 95

1. Is this true?
2. Yes.
3. Execute the statement(s) it guards and proceed to whatever follows the If-elif-else

If-Elif-Else: How it Works

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

x ---> 65

1. Is this true?
2. No.
3. Proceed to the next comparison.

If-Elif-Else: How it Works

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

x ---> 65

1. Is this true?
2. No.
3. Proceed to the next comparison.

If-Elif-Else: How it Works

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

x ---> 65

1. Is this true?
2. No.
3. Execute "the else"
4. Proceed to what follows the if-elif-else.

Equivalent Scripts

```
x = input('Score: ')
if x>=90:
    grade = 'A'
elif x>=80:
    grade = 'B'
elif x>=70:
    grade = 'C'
else:
    grade = 'U'
print grade
```

```
x = input('Score: ')
if x>=90:
    print 'A'
elif x>=80:
    print 'B'
elif x>=70:
    print 'C'
else:
    print 'U'
```

I prefer the one on the left. The letter grade is an essential feature of the computation and having a variable that houses it reminds me of that fact,

Legal Not to Have the "Else"

```
grade = 'B'
nApples = input('#Apples sent to Prof:')
if nApples<10:
    grade = grade + '-'
print grade
```

Let's review all the "if" variations…

Standard `if-else`

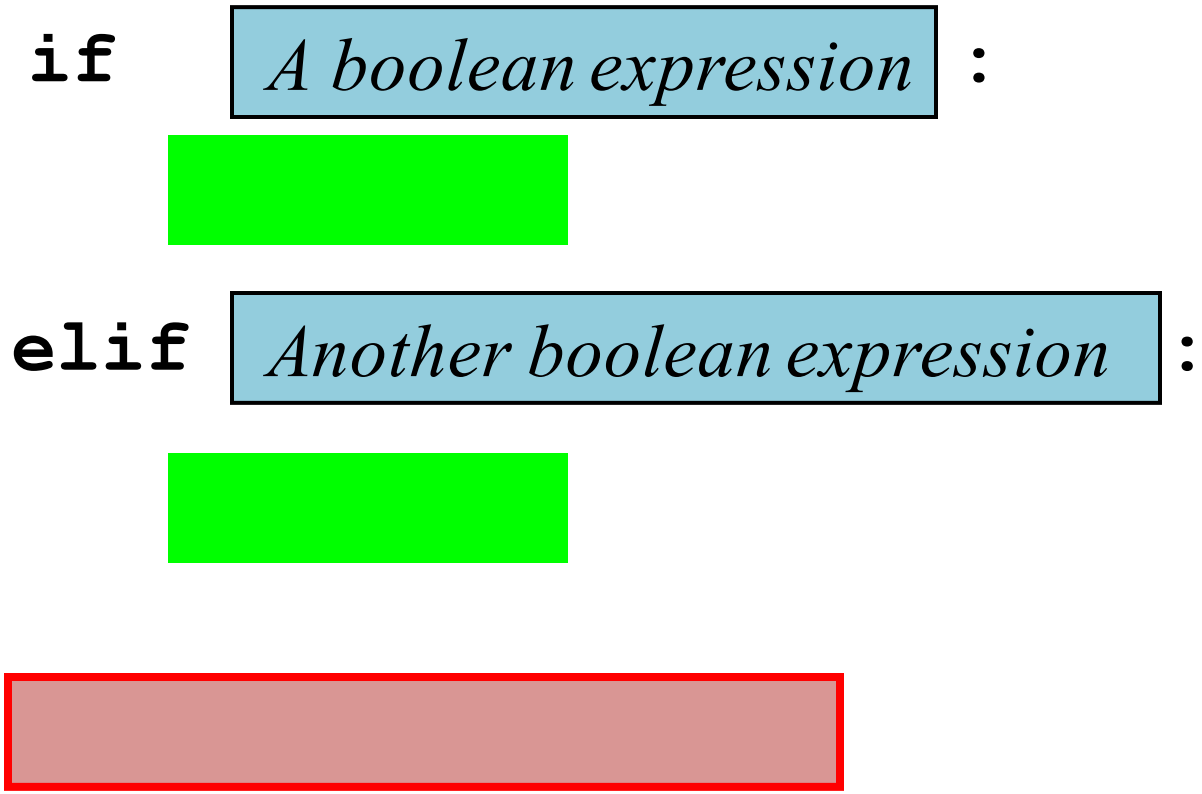
`if` *A boolean expression* **`:`**

`else:`

Code that is executed after the whole "if" is processed.

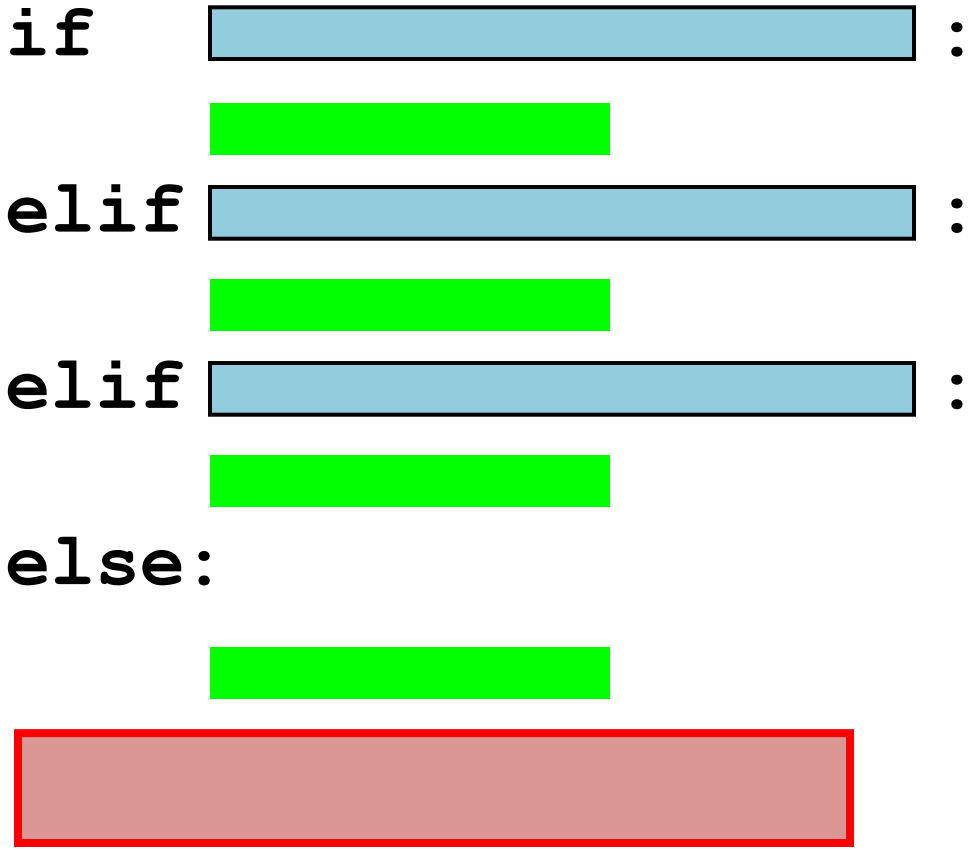
Exactly one of the green boxes is executed

if-elif



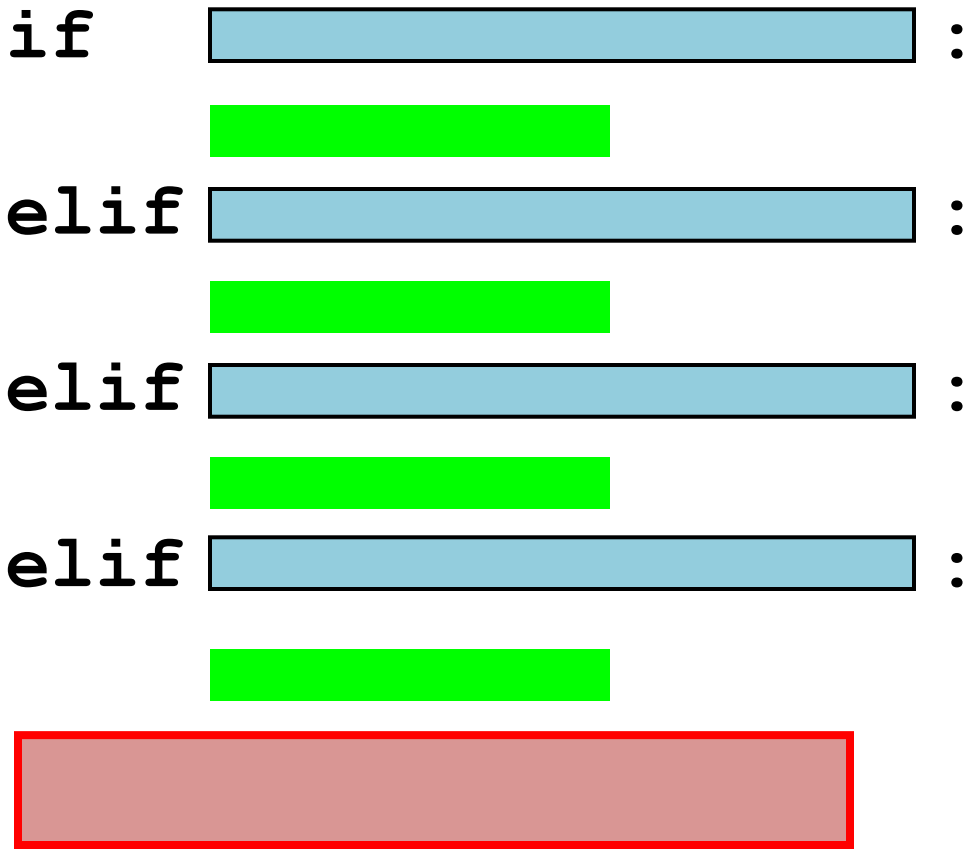
If both boolean expressions are false, no green box is executed.
Otherwise, the "first" green box that is "guarded" by a true boolean expression is executed.

Multiple `if-elif` With Else



The first green box guarded by a true boolean expression is executed.
If they are all false, then the else's green box is executed.

Multiple `if-elif` With No Else



Note that if all the boolean expressions are False, then no green code is executed. Otherwise the first green box guarded by a true boolean expression is executed

More Complicated Boolean Expressions

`x --->` 3 `y --->` 6 `z --->` 9

```
(x < y) and (x < z)      True
(x > y) and (x < z)      False
(x < y) and (x > z)      False
(x > y) and (x > z)      False
```

This showcases the `and` operator.

The and Operator

   **and** 

True	**True**	**True**
True	**False**	**False**
False	**True**	**False**
False	**False**	**False**

Here  and  are Boolean-valued expressions

More Complicated Boolean Expressions

x ---> 3 y ---> 6 z ---> 9

```
(x < y) or (x < z)      True
(x > y) or (x < z)      True
(x < y) or (x > z)      True
(x > y) or (x > z)      False
```

This showcases the `or` operator.

Example

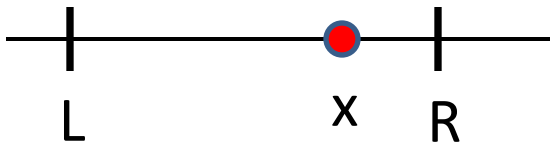
Fact: A length-4 string is a palindrome if
The first and last characters are the same and
The middle two characters are the same

```
s = input('s: ')

if (s[0]==s[3]) and (s[1]==s[2]):
    print 'palindrome'
else:
    print 'not a palindrome'
```

Example

Fact: x is inside the interval [L,R] if it is no smaller than L and no bigger than R.

```
x = input('x:  ')
L = input('L:  ')
R = input('R:  ')

if (L<=x) and (x<=R):
    print 'Inside'
else:
    print 'Outside'
```

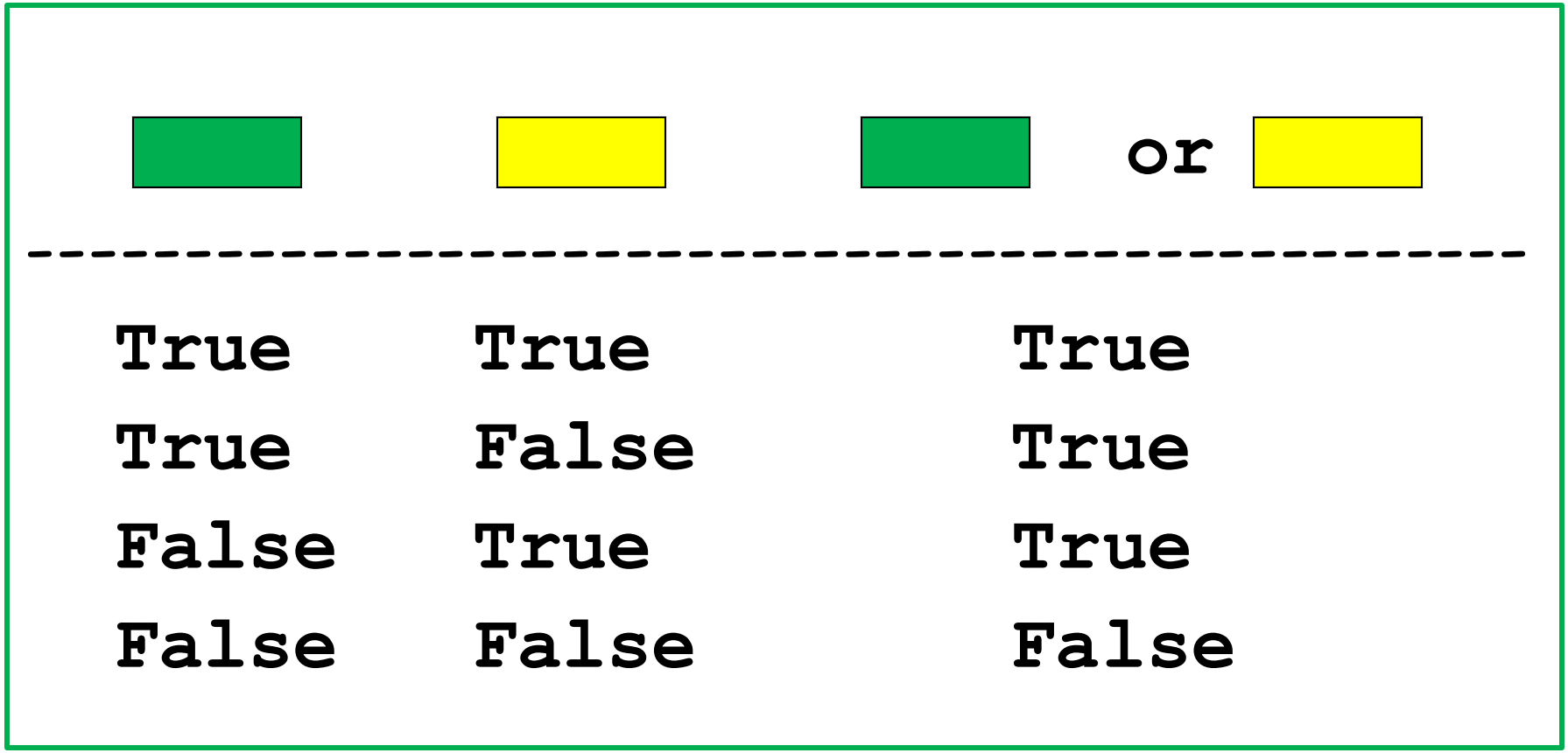


Equivalent Solution

```
x = input('x: ')
L = input('L: ')
R = input('R: ')

if (L<=x) and (x<=R):
    print 'Inside'
else:
    print 'Outside'
```

```
x = input('x: ')
L = input('L: ')
R = input('R: ')

if L<=x<=R :
    print 'Inside'
else:
    print 'Outside'
```

The or Operator



Here  and  are boolean-valued expressions

Example

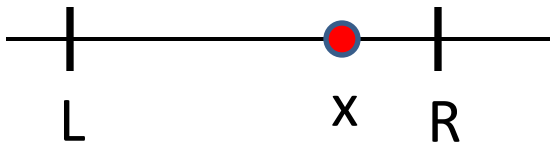
Fact: A length-4 string is a partial palindrome if the first and last characters are the same or if the middle two characters are the same

```
s = input('s: ')

if (s[0]==s[3]) or (s[1]==s[2]):
   print 'partial palindrome'
else:
   print 'not a partial palindrome'
```

Example

Fact: x is inside the interval [L,R] if it is no smaller than L and no bigger than R.

```
x = input('x:  ')
L = input('L:  ')
R = input('R:  ')

if (x<L) or (R<x):
   print 'Outside'
else:
   print 'Inside'
```



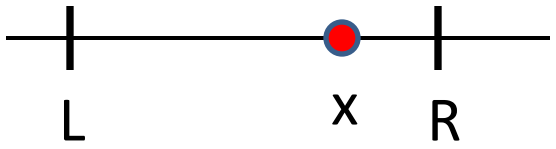
Example

Fact: x is inside the interval [L,R] if it is no smaller than L and no bigger than R.

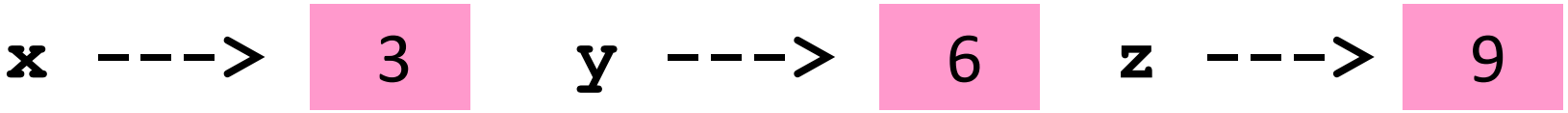
```
if (x<L) or (R<x):
   print 'Outside'
else:
   print 'Inside'
```

```
if (L<=x) and (x<=R):
   print 'Inside'
else:
   print 'Outside'
```

Often you can arrange a conditional execution in several ways.



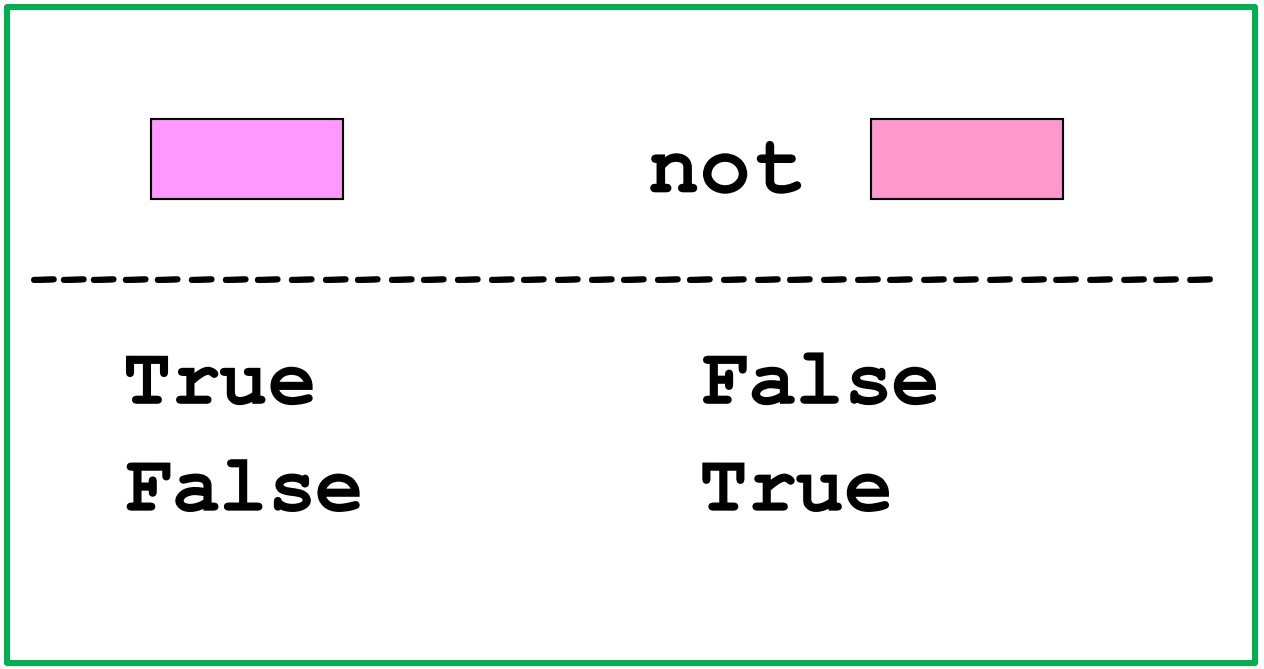
More Complicated Boolean Expressions




```
not (x < y)      False
not (x > y)      True
```

This showcases the `not` operator.

The `not` Operator



Here  is a boolean-valued expression

A Summarizing Example

Input a string. If it has even length, then hyphenate in the middle:

baseball base-ball

If it has odd length, then hyphenate around the middle character:

frisbee fri-s-bee

The `len` Function

If ever you need to compute the length of a string then use the built-in function **`len`**.

```
s = 'abcdef'
n = len(s)
m = n/2
First = s[:m]
Second = s[m:]
```

x ---> 'abcdef'

n ---> 6

m ---> 3

First ---> 'abc'

Second ---> 'def'

The `len` Function

If ever you need to compute the length of a string then use the built-in function **`len`**.

```
s = 'abcdefg'
n = len(s)
m = n/2
First = s[:m]
Second = s[m:]
```

`x` ---> 'abcdefg'

`n` ---> 7

`m` ---> 3

`First` ---> 'abc'

`Second` ---> 'defg'

So Let's Solve this Problem

Input a string. If it has even length, then hyphenate in the middle:

baseball base-ball

If it has odd length, then hyphenate around the middle character:

frisbee fri-s-bee

Developing a Solution

Instead of just showing the solution, let's "derive" the solution using a methodology that is called stepwise refinement.

The course is really about problem solving with the computer.
So developing problem-solving strategies is VERY IMPORTANT

"Reformat" the task.

```
Read in the string
Compute its length
if the length is even
    Hyphenate in the middle
else
    Hyphenate around around the middle
    character.
```

Still in English, but it looks a little more like python.

"Reformat" the task.

```
Read in the string
Compute its length
if the length is even
    Hyphenate in the middle
else
    Hyphenate around around the middle
    character.
```

Turn these into Python

Refine

```
s = input('Enter a string: ')
n = len(s)
if the length is even
    Hyphenate in the middle
else
    Hyphenate around around the middle
    character.
```

We have turned the first two lines into python.

Refine Some More

```
s = input('Enter a string: ')
n = len(s)
if the length is even
    Hyphenate in the middle
else
    Hyphenate around around the middle
    character.
```

How do we check if the value in n is even?

Refine Some More

```
h = input('Enter a string: ')
n = len(s)
if n%2==0:
    # s has even length
    Hyphenate in the middle
else:
    # s has odd length
    Hyphenate around around the middle
    character.
```

We add comments to summarize what we may assume about the value of n.

Refine Some More

```
h = input('Enter a string: ')
n = len(s)
if n%2==0:
    # s has even length
    Hyphenate in the middle
else:
    # s has odd length
    Hyphenate around around the middle
    character.
```

Figure out the even-length hyphenation

Even-Length Hyphenation

We look at a small example.

These statements

```
s = 'abcdef'
h = s[0:3] + '-' + s[3:]
```

assign `'abc-def'` to `h`.

In general:

```
m = n/2
h = s[0:m] + '-' + s[m:]
```

Refine Some More

```
h = input('Enter a string: ')
n = len(s)
if n%2==0:
    # s has even length
    m = n/2
    h = s[0:m] + '-' + s[m:]
else:
    # s has odd length
    Hyphenate around around the middle
    character.
```

Refine Some More

```
h = input('Enter a string: ')
n = len(s)
if n%2==0:
    # s has even length
     m = n/2
     h = s[0:m] + '-' + s[m:]
else:
    # s has odd length
```

Hyphenate around around the middle character.

Figure out the odd-length hyphenation

Odd-Length Hyphenation

We look at a small example.

This

```
s = 'abcdefg'
h = s[0:3] + '-' + s[3] + '-' + s[3:]
```

assigns `'abc-d-efg'` to `h`.

In general:

```
m = n/2
h = s[0:m] + '-' + s[m] + '-'+ s[m+1:]
```

Done!

```
h = input('Enter a string: ')
n = len(s)
if n%2==0:
    # s has even length
    m = n/2
    h = s[0:m] + '-' + s[m:]
else:
    # s has odd length
    m = n/2
    h = s[0:m]+'-'+s[m]+'-'+s[m+1:]
```

Summary

1. A Boolean expression evaluates to either True or False
2. A Boolean expression is made up of comparisons that are either True or False
3. The and, or, not operations combine boolean values
4. Various if constructions can be used to organize conditional execution.

Terminology

boolean

A primitive type whose values are True and False.

Reference: http://www.cs.cornell.edu/Courses/cs1110/2015sp/materials/definitions.php