Session 2: If statements and For loops

Watch videos 7 and 9 of this Python tutorial playlist if you missed this session: link

See here for last week's content.

If statements

We often want our programs to adapt their behaviour based on the input they receive. For instance, lets say we want to create a program, which tells our user if the number they input is small (e.g. less than 10). This is what the next program does:

```
number = int(input("Please enter a number: "))
if number < 10:
  print(number + " is a small number.")
```

We could also have our program say something if the number is large as well:

```
number = int(input("Please enter a number: "))
if number < 10:
  print(number + " is a small number.")
else:
  print(number + " is a large number.")
```

We can read the above as

> if "this condition is true" then "execute this code", otherwise "execute this other code"

We can generalise the first example as:

```
if condition_is_true:
  execute_this_code
```

And the second one as:

```
if condition_is_true:
  execute_this_code
else:
  this_code_is_executed_otherwise
```

Notice that we write "then" as `:`. The most important thing to notice is that we execute the indented code *only* when the condition holds.

We can write any number of statements inside the **body** of the `if` statement, i.e. statements that are indented (press `TAB`) will only be executed if the condition of the `if` statement holds.

There are several important concepts to note here:

- If we want to compare two values (e.g. the value the user entered and a fixed string) we use `==` instead of `=` (remember, `=` means *becomes*)
- We can compare numbers and strings using the comparison operators `==`, `!=` (not equal), `<=` (less than or equal), `>=` (greater than or equal), `<` (less than), and `>` (greater than)
- `if` statements can be nested

`elif`

We can also abbreviate the following:

```
number = int(input("Please enter a number: "))
if number < 10:
  print("This number is small.")
else:
  if number >= 10 and number < 100:
    print("This number is not small, but not large either.")
  else:
    print("This number is large.")
```

to

```
number = int(input("Please enter a number: "))
if number < 10:
  print("This number is small.")
elif number >= 10 and number < 100:
  print("This number is not small, but not large either.")
else:
  print("This number is large.")
```

You can have as many `elif` branches as you like, but only one `if` branch and one `else` branch, which must appear at the beginning and end respectively.

`and` `or` `not`

Here we used the keyword `and` to mean that we want both `number >= 10` and `number < 100` to be true for that branch to be executed. You could use `or` and `not` in expressions, e.g.

```
number = int(input("Please enter a number: "))
if not number < 10:
  # Will be executed if number is not less than 10 (i.e. if number >= 10)
  print("The number is not less than 10.")
```

```
if number == 3 or number == 4:
  # Will be executed if number is equal to 3 or equal to 4
  # Note that comparison is done with == rather than =
  print("The number is either 3 or 4.")
```

If you are using multiple different connectives, you should include parentheses to make it clear how the expression should be interpreted. E.g.

```
number = int(input("Please enter a number: "))
if ((1 <= number and number < 10) or number == 42) and (not number == 3):
  print("This was the number: " + str(number))
```

This code will only print `number` if it is one of the numbers [1, 2, 4, 5, 6, 7, 8, 9, 42].

Note: there is an order of operations on logical connectives as well (which you may wish to google); however, it is recommended that you insert parentheses if you are using multiple different connectives, like in the example above.

It's important to remember that an `else` statement (or an `elif`) statement is associated with the closest `if` statement above it, which has the same indentation (same number of `TAB`s before it). So consider the program:

```
name = input("Please enter a name: ")
if name == "Mark":
  print("Oh, hi Mark.")
if name == "Johnny":
  print("Oh, hi Johnny.")
else:
  print("Who is this?")
```

You might think that if the name input is 'Mark' it will print 'Oh, hi Mark.' if it's Johnny, it will print 'Oh, hey Johnny, what's up?', and otherwise it will print 'Who is this?'. But actually, if the name is Mark, it will print both 'Oh, hi Mark' and 'Who is this?'. This is because the `else` statement is only associated with the `if` just above it. The first `if` is completely independent. You might find it helpful to think about the program split as so:

```
name = input("Please enter a name: ")
```

```
if name == "Mark":
  print("Oh, hi Mark.")
```

```
if name == "Johnny":
  print("Oh, hey Johnny, what's up?")
```

```
else:
  print("Who is this?")
```

The correct way to write the above program is using an `elif`:

```
name = input("Please enter a name: ")
if name == "Mark":
  print("Oh, hi Mark.")
elif name == "Johnny":
  print("Oh, hey Johnny, what's up?")
else:
  print("Who is this?")
```

Exercise 1. **One detector**

Create a program, which takes an input (an int) and outputs "The number is 1" if the input was 1 and "The number is not 1" otherwise.

Exercise 2. **Subtraction**

Create a program, which takes two integers, and outputs the result of the larger number subtracting the smaller number.

```
Input first number: 4
Input second number: 3
The answer of 4-3 is 1

Input first number: 3
Input second number: 4
The answer of 4-3 is 1
```

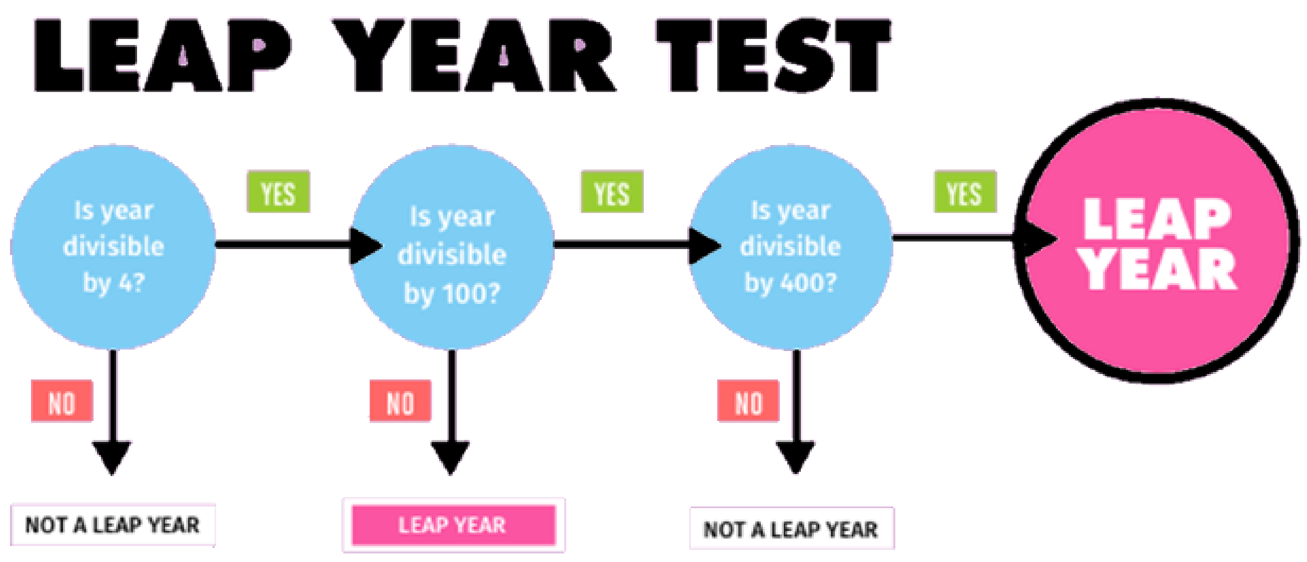
Exercise 3. **Award**

Students can only get an award if they get a score of 60 or more and get an "A" for conduct. Create a program, which takes one integer (a score) and one string (a conduct grade), and tell whether the student could get an award.

```
Enter score: 88
Enter conduct grade: A
Congratulations! You get an award.

Enter score: 88
Enter conduct grade: B
Your conduct grade is not A.

Enter score: 40
Enter conduct grade: A
Your score is not high enough.

Enter score: 40
Enter conduct grade: C
Your score is not high enough and your conduct grade is not A.
```

Exercise 4. **Leap Year:**

Create a program that determines whether a year is a leap year.



(*Recall: a % b gives the remainder when a is divided by b*)

```
Enter year: 2022
2022 is not a leap year

Enter year: 2020
2020 is a leap year

Enter year: 2000
2000 is a leap year

Enter year: 1900
1900 is not a leap year
```

For highest marks, achieve the same result by only using one `if`, one `else`, and no `elif`s. (Remember, you can use `and`, `or`, and `not` to build complex conditions.)

You can find all the solutions here.

The need for looping

Imagine you have to print a square of *s using Python.

```
**********
*        *
*        *
*        *
*        *
*        *
*        *
*        *
*        *
**********
```

One solution is to do this:

```
print("**********")
print("*        *")
print("*        *")
print("*        *")
print("*        *")
print("*        *")
print("*        *")
print("*        *")
print("*        *")
print("**********")
```

But don't you think it is too repetitive? This is when loops come in handy. They allow you to repeatedly run the same piece of code multiple times. There are two types of loops, for and while loops.

For loops

Runs the body a specified number of times.

For example, to print the same square as the one above, we can do:

```
print("**********")
for i in range(8):
    print("*        *")
print("**********")
```

`range(8)` means that the statements indented will be run 8 times, in other words, 8 **iterations**. Indentation is important to specify which statements are in the for loop and which ones are not.

What is i?

Let's try to print the value i in every iteration.

```
for i in range(5):
    print(i)

# 0
# 1
# 2
# 3
# 4
```

The variable `i` consecutively takes all values from 0 to n-1, it helps us to keep track of our progress while looping, the following example uses the value `i` to print out the first `n` non-negative even numbers.

```
n = int(input("Input a number: "))

for i in range(n):
    print(i*2)
```

It is common to use variable names like `i`, `j`, `k` for iteration.

It is also common for us to be wanting to iterate from 1 to n instead of from 0 to n-1. In this case, we can use `range(1,n+1)`, meaning that it will loop from 1 to n+1, including 1 but excluding n+1. That means looping from 1 to n inclusive. The following code prints out the first `n` positive even numbers. (excluding 0)

```
n = int(input("Input a number: "))

for i in range(1,n+1):
    print(i*2)
```

Short aside: incrementing numbers

We've seen before that we can do:

```
number = 1
print(number + 1) # Prints '2'
print(number) # Prints '1'
```

But what if we want to actually increase the values of `number`? We might be tempted to do:

```
number = 1
number + 1
print(number) # Still prints '1'
```

But that doesn't change `number` at all: it just asks Python to evaluate what `number + 1` is. The way to actually increment `number` is:

```
number = 1
number = number + 1
print(number) # Prints '2'
```

This might seem a bit confusing at first, since `number` appears both on the left and on the right of the `=`. The rule in Python is that stuff on the right side of and `=` are evaluated before stuff on the left side. You can think about the above code like it was shorthand for this:

```
number = 1
temp = number + 1
number = temp
print(number)
```

Another way to do this exact same thing is:

```
number = 1
number += 1
print(number)
```

Here, the `+=` operator is used as a shorthand for writing `number = number + 1`. These kinds of shorthands are usually referred to as *syntactic sugar* in programming - it's shorter so it's "sweeter" for people to read and write. There are analogous operators: `-=`, `*=`, `/=`, etc.

```
number = 1
number += 2
number -= 3
number *= 4
number /= 5
# ...
```

If unsure, just use the first form: `number = number + 1`.

In the specific case when we have `number += 1` (i.e. we have `1` on the right-hand side) we say that we **increment** `number`. When we do `number -= 1` we say that we **decrement** `number`.

Worked example: summing from 1 to `n`

The following example sums the first `n` natural numbers, including `n`.

```
n = int(input("Please enter a number: "))

sum = 0
for i in range(1,n+1):
    sum += i

print("The sum of the first " + str(n) + " natural numbers is " + str(sum))
```

Exercise 5.

Read the following code blocks and predict their results.

```
for i in range(4,10):
  print(i)
```

```
for i in range(0,10,2):
  print(i)
```

```
for i in range(5, 0):
  print("Backwards: " + str(i))
for i in range(5):
  print("Subtraction: " + str(5 - i))
```

Now run the code. What happens? Is this what you expected?

Exercise 6. **Powers**

Complete the program below, which outputs the first `n` powers of 2. (You are not allowed to use the exponentiation operator `**`.)

```
n = ___(input("Input a number: "))
number = 1
for i in range(_____):
    number____________
    print(number)
```

```
Input a number: 5
2
4
8
```

```
16
32
```

Exercise 7.

Write a program which asks the user for an input `n`, and then prompts them for `n` numbers. Then, it prints out the average of those `n` numbers. A run of your program might look something like this:

~~~
```
How many numbers? 3
Please enter a number: 1
Please enter a number: 2.5
Please enter a number: 7
The average was: 3.5
```
~~~

Note that this program accepts decimal inputs, so you should cast to `float` instead of `int`.

```
# Reminder: casting to float preserves decimals
float("5.5") # will be 5.5
int("5.5") # will be 5
```

Exercise 8. **Fibonacci**

Complete the program below, which outputs the first `n` fibonacci numbers. (Each number is the sum of the two preceding ones, starting with 0,1.)

```
t = ______(input("Input a number: "))
a = 0
b = 1
for ______ in range(t):
    c = a + b # calculate new term
    #shift the terms by 1
    a = ____
    b = ____
print("Term " + str(i) + " is " + _____________)
```

```
Input a number: 5
Term 0 is 0
Term 1 is 1
Term 2 is 1
Term 3 is 2
Term 4 is 3
Term 5 is 5
```

Information for testing purposes: the 14th term in the Fibonacci sequence is 377.

Exercise 9. **Pyramid**

Read the following code and predict its result.

```
print("rock paper scissors:")
print()
print("rock", end=", ")
print("paper", end=", ")
print("scissors", end="! ")
print("play again?")
```

Based on that, create a program which takes as input a number n and then prints the following:

```
1

1 2

1 2 3

.............

1 2 3 4 ... n
```

Exercise 10. **Square**

Create a program which prints a square of *s of size n based on input. As a generalisation of the example.

```
Side length of the square: 10
**********
*        *
*        *
*        *
*        *
*        *
*        *
*        *
*        *
**********
```

Once you've done this with loops, consider: is there a good place to use string "multiplication" and string "addition"? It may be useful to read the following code and predict its result:

```
print("rock\npaper\nscissors!")
```

For highest marks, your program should output 1 star when n is 1, and no stars when n <= 0.

You can find all the solutions here.