Lecture 07

Selection Statements: `if`, `elif`, and `else`.

26 Pluviôse, Year CCXXX

Song of the day: ***Piplup Step*** *by Serph feat. ずん (2022).*

Recall our debugged code from last week:

```
# Constants
lower_credit_limit = 40
upper_credit_limit = 64

# Asking for user input
dean_permission_input = input("Do you have permission from the dean? [y/n] ")
advisor_permission_input = input("Do you have permission from your advisor? [y/n] "
senior_status_input = input("Do you hold senior status? [y/n] ")
accumulated_credits = float(input("How many credits do you have? "))

# Student information
has_dean_permission = dean_permission_input == 'y'
has_advisor_permission = has_dean_permission == 'y'
is_approved_senior = senior_status_input == 'y'

# Generating permission
condition_one = accumulated_credits >= upper_credit_limit and is_approved_senior
condition_two = accumulated_credits >= lower_credit_limit and has_advisor_permissio

can_graduate = has_dean_permission or condition_one or condition_two

# Graduation status display
print("This student can graduate:", can_graduate)
```

To recap, we used a series of compound boolean statements to determine wheather or not a student could graduate (i.e. a `True - False`, or binary, situation).

The ability to determine whether something is true or not is hugely important to computer science; it is what determines whether we get access to our email accounts, whether a bank's fraud alert system blocks your account if it sees suspicious activity, and whether an autonomous vehicle changes lanes depending on the traffic surrounding it. We have done something similar above, but something is missing.

It turns out that just being able to determine whether something is true or not is not quite enough for this program to be very useful. In fact, what makes Python, and all programming languages, (infinitely, literally) more powerful than being simply fancy calculators that can solve inequalities is not their ability to tell us whether something is true or not, but rather ***its ability to do different sets of instructions whether something is true or not***. (In fact, the ability to do this is the single thing that makes a computer **Turing complete**. If you don't know what this is and/or want to watch an amazing video talking about it, click **here**)

To give a familiar example, what if we wanted our program above to not only tell us whether the student can graduate or not, but also tell us the reasons *why* the student can graduate:

```
Do you have permission from the dean? [y/n] n
Do you have permission from your advisor? [y/n] n
Do you hold senior status? [y/n] y
How many credits do you have? 20
You cannot graduate.
```

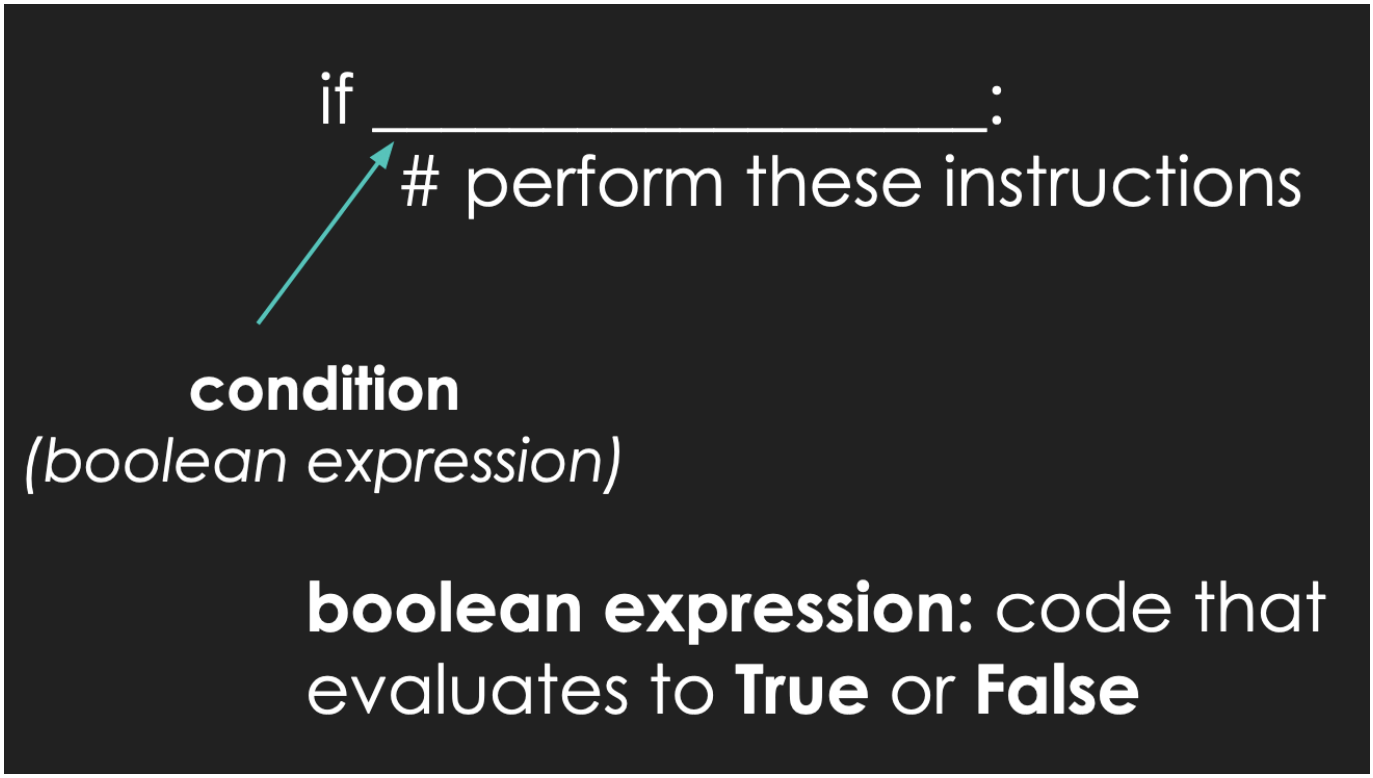
```
Do you have permission from the dean? [y/n] n
Do you have permission from your advisor? [y/n] n
Do you hold senior status? [y/n] y
How many credits do you have? 65
You can graduate because you are an approved senior with 65.0 credits. Congrats!
```

```
Do you have permission from the dean? [y/n] n
Do you have permission from your advisor? [y/n] y
Do you hold senior status? [y/n] n
How many credits do you have? 50
You can graduate because you the minimum credits (50.0) to do so. Congrats!
```

With our current Python prowess, we cannot ask our programs to produce different output depending on the results of an operation. That will change today. Say hello to selection statements `if`, `elif`, and `else`.

Part 1: `if` *-Statements*

The first of these selection statements is the mother of all computer science structures—the `if` statement. Here's the basic Python syntax:



If we wanted to say this in plain English, it would just simply say:

> **If** a certain condition is **true**, perform these instructions **once**.

For example, let's say that we were programming NYU's COVID screening system, and a use can only enter the building if they are a student **and** if they are triple vaccinated:

```
student_status_input = input("Is this student's ID active? [y/n] ")
booster_status_input = input("Has this student received their COVID-19 booster shot

is_student = student_status_input == 'y'
is_triple_vaxxed = booster_status_input == 'y'

if is_student and is_triple_vaxxed:
    # Statements that are indented under an if-statement will execute if is_student
    print("This student is allowed in the building.")
```

This would read as:

> **If** this person is a student **and if** this person has had their booster shot, then print the following message:

> "This student is allowed in the building if they are a student and if they are triple-vaccinated."

Notice that I don't say here `"if they are a student and are triple-vaccinated"`. This is because Python considers each clause **completely independent** of others. For example, imagine that a certain instruction would only be executed if the user input was either `'y'` or `'Y'`. This would have to be written in Python as such:

```
user_input = input("Would you like to continue? [y/n] ")

if user_input == 'y' or user_input == 'Y':
    # Do something
```

You should ***not*** tye it this way, in other words:

```
user_input = input("Would you like to continue? [y/n] ")

if user_input == 'y' or 'Y':
    # Do something
```

Why? Because, read as a Python interpreter, this would read as:

> If the value of `user_input` is equal to `'y'`, **or** the value of `'Y'` is `True`, then execute.

And this is clearly not what we're trying to say. So you have to be careful when writing your conditions; just because something reads a certain way in English, it does not necessarily mean that it translates exactly into Python.

Part 2: `else` *-Statements*

So now we know how to have an instruction or set instructions execute whenever a condition or set of conditions are true. So what happens in the case where we want a specific set of instructions to execute when a condition evaluates to false? Let's say a certain American alcohol-related website asks you to input your birth-year, and if it determines that you are under 21, it will give you a different message. If we only use `if`-statements, we cannot achieve this sort of "forking", since the program's flow will always go from top to bottom:

```
CURRENT_YEAR = 2022
AMERICAN_DRINKING_AGE = 21
```

```
user_age = int(input("What year were you born in? "))
difference = CURRENT_YEAR - user_age  # here, we assume that the input will alway

if difference >= AMERICAN_DRINKING_AGE:
    print("Welcome!")
```

Note: Look at the syntax for constant values (`CURRENT_YEAR` and `AMERICAN_DRINKING_AGE`). This is the correct way to define constants in Python, regardless of which case system you are using. I will be using this convention in class from now on.

In order to add a second "option" for this program to execute in such case that this user is under 21, we need to use the complementary statement to `if` : the `else` -statement:

```
CURRENT_YEAR = 2022
AMERICAN_DRINKING_AGE = 21

user_age = int(input("What year were you born in? "))
difference = CURRENT_YEAR - user_age  # here, we assume that the input will always

if difference >= AMERICAN_DRINKING_AGE:
    print("Welcome!")
else:
    # Statements that are indented under the else-statement will only execute if the
    print("No entry for underage users.")
```

This, in English, would read as:

> **If** the value of `difference` is greater than or equal to the value of `AMERICAN_DRINKING_AGE` , print `"Welcome!"` . **Or else** (i.e. if it is **not** greater than or equal to the value of `AMERICAN_DRINKING_AGE`) print `"No entry for underage users."` .

Or, perhaps more closely following Python syntax:

> Execute `print("Welcome!")` **if** the expression `difference >= AMERICAN_DRINKING_AGE` evaluates to `True` , or **else** (i.e. if not) execute `print("No entry for underage users.")` .

Either way of reading it describes the same behaviour. See the sample executions below:

```
What year were you born in? 1993
Welcome!
```

```
What year were you born in? 2004
No entry for underage users.
```

There are a couple of things of note about the `else` keyword:

- It cannot exist by itself. It needs to be preceded by either an `if` - or an `elif` -statement. More about the latter in a bit.
- It does not take a condition after it, the way `if` does. In other words, you cannot do the following:

```
if difference >= AMERICAN_DRINKING_AGE:
    print("Welcome!")
else difference < AMERICAN_DRINKING_AGE:  # WRONG
    print("No entry for underage users.")
```

This makes sense if you think about the fact that an `if - else` structure represents a **binary** fork in your program. In other words, if it is not one, it *has* to be the other, so there's no need to tell Python what the other is.

This can pose a bit of danger when writing certain programs because if you don't cover all of your bases, the `else` -statement can execute in unexpected cases:

```
LIMIT = 100.0

height = float(input("Enter any value under 100.0 for the height of your rectangle:
width = float(input("Enter any value under 100.0 for the width of your rectangle: "

if height < LIMIT and width < LIMIT:
    area_of_rectagle = height * width
    print("The area of your rectangle is:", area_of_rectagle)
else:
    print("Please enter values under 100.0")
```

When executed:

```
Enter any value under 100.0 for the height of your rectangle: 42
Enter any value under 100.0 for the width of your rectangle: -50.45
The area of your rectangle is: -2118.9
```

Naturally, negative lengths and areas don't make any sense, but the only condition you gave Python in your `if` -statement was that the value should be under `100.0` ; you didn't account for the possibility of values `< 0.0` . A better implementation of this program might instead be:

```
LOWER_LIMIT = 0.0
UPPER_LIMIT = 100.0

height = float(input("Enter any value under 100.0 for the height of your rectangle:
width = float(input("Enter any value under 100.0 for the width of your rectangle:

if LOWER_LIMIT < height < UPPER_LIMIT and LOWER_LIMIT < width < UPPER_LIMIT:
    area_of_rectagle = height * width
    print("The area of your rectangle is:", area_of_rectagle)
else:
    print("Please enter positive values under 100.0")
```

Sample execution:

```
Enter any value under 100.0 for the height of your rectangle: 42
Enter any value under 100.0 for the width of your rectangle: -54.45
Please enter positive values under 100.0
```

Part 3: `elif` *-Statements*

I actually think we can do better that the implementation above. Especially with ranges, you might have a specific set of instructions execute if "condition 1" is true, a different set if "condition 2" is true, a third set if "condition 3" is true, etc.. A lot of "choices" in programming and software development are not simply binary, but rather can include three, four, or even thousands of different paths depending on the situation. For example, let's go back to our age-check program. If the user enters a negative number, our site will of course not let them in. But what if we wanted to instead tell them that the value that they entered is invalid, instead of telling them that they are underaged? This may seem like a minor change, but in terms of user experience, it may make a world of difference for the clients using your web app.

In programming, we can achieve this multi-branching by using the "else if" statement, or the `elif` -statement in Python.

```
CURRENT_YEAR = 2022
AMERICAN_DRINKING_AGE = 21

user_age = int(input("What year were you born in? "))
```

```
difference = CURRENT_YEAR - user_age

if user_age < 0:
    print("Invalid input")
elif difference >= AMERICAN_DRINKING_AGE:
    print("Welcome!")
else:
    print("No entry for underage users.")
```

This, in English, would read as:

> If the value of `user_age` is negative, print `"Invalid input"`.
>
> If the value of `difference` is greater than or equal to the value of `AMERICAN_DRINKING_AGE`, print `"Welcome!"`.
>
> If neither of these conditions are true, then print `"No entry for underage users."`.

Immediately we notice the biggest difference between `elif` and `else`: just like `if`-statements, `elif`-statements **must take a condition**.

This is because you are telling Python to consider several sets of options. It will consider them all in order, and if none of them evaluate to `True`, it will execute whatever instructions exist under the `else`-statement, if any.

The great thing about `elif`, too, is that you can have several of them in one `if-elif-else` block. What happens if the user enters a year that is greater than 2022? The value of `difference` would then be negative:

```
What year were you born in? 2030
No entry for underage users.
```

While this is...technically true, it still doesn't make much sense. A better way to implement this program would be:

```
CURRENT_YEAR = 2022
AMERICAN_DRINKING_AGE = 21

user_age = int(input("What year were you born in? "))
difference = CURRENT_YEAR - user_age

if user_age < 0:
    print("Invalid input")
elif difference < 0:
```

```
    print("No entry for unborn users.")
elif difference >= AMERICAN_DRINKING_AGE:
    print("Welcome!")
else:
    print("No entry for underage users.")
```

Output:

```
What year were you born in? 2030
No entry for unborn users.
```

Part 3: *Common Mistakes*

Two things happen rather often when first starting out with branching.

The first is the order of your `if` s and `elifs` . What would have happened it my age check code were instead implemented this way:

```
CURRENT_YEAR = 2022
AMERICAN_DRINKING_AGE = 21

user_age = int(input("What year were you born in? "))
difference = CURRENT_YEAR - user_age

if difference >= AMERICAN_DRINKING_AGE:
    print("Welcome!")
elif user_age < 0:
    print("Invalid input")
elif difference < 0:
    print("No entry for unborn users.")
else:
    print("No entry for underage users.")
```

We are still checking for the same four different possibilities, right? The big problem here is that Python does **not** check all four options at the same time. It checks them one-by-one, from top to bottom.

```
What year were you born in? -40
Welcome!
```

That's clearly not right. What happened here is that Python first checked the `if` -statement condition, which only cares about `difference` being less than `AMERICAN_DRINKING_AGE` . If

we enter `-40` for our birth year, the value of `difference` would be `2062`. So, yeah, you can drink if you are 2062 years old, but that is not the point here. We have a very specific set of instructions to execute in such case that the user enters a negative number.

In general, the broadest conditions should go first, and get more specific as you add more `elif`-statements.

The second thing that always comes up is the question:

> How do I know if I should use `elif`s or just several `if`-statements?

Let's replace all of our `elif`-statements from before and see what happens:

```
CURRENT_YEAR = 2022
AMERICAN_DRINKING_AGE = 21

user_age = int(input("What year were you born in? "))
difference = CURRENT_YEAR - user_age

if difference >= AMERICAN_DRINKING_AGE:
    print("Welcome!")
if user_age < 0:
    print("Invalid input")
if difference < 0:
    print("No entry for unborn users.")
else:
    print("No entry for underage users.")
```

- *Example #1*:

```
What year were you born in? 1993
Welcome!
No entry for underage users.
```

- *Example #2*:

```
What year were you born in? >? -1989
Welcome!
Invalid input
No entry for underage users.
```

What went wrong? The problem here is that **every time Python sees an `if` -statement, it will execute it**. In other words, using only `if` -statements is not like taking a single path of a series of option, but rather like taking several single paths of only two options.