Branching In Python: Part 2

- Using logic in conjunction with branching
- Multiple IFs
- IF-ELIF
- Nested branches
- The IF-IN operator

James Tam

Decision-Making With Multiple Boolean Expressions (Connected With Logic)

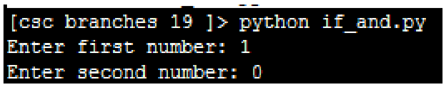
Multiple brackets aren't mandatory with python but are required with other languages (a good idea to get into including them).

- **Format:**

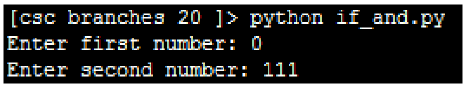
```
if ((Boolean expression) logical operator (Boolean expression)):
    body
```

- **Example:** 4if_and_positive.py
  - Learning objective of example: applying logical AND (all Boolean expressions must evaluate to true for compound expression to be true).

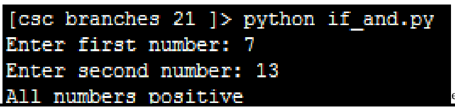
```
if ((x > 0) and (y > 0)):
    print("All numbers positive")
```



```
[csc branches 19 ]> python if_and.py
Enter first number: 1
Enter second number: 0
```



```
[csc branches 20 ]> python if_and.py
Enter first number: 0
Enter second number: 111
```



```
[csc branches 21 ]> python if_and.py
Enter first number: 7
Enter second number: 13
All numbers positive
```

es Tam

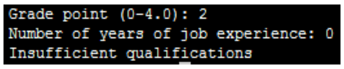
Forming Compound Boolean Expressions With The "OR" Operator

- **Format:**

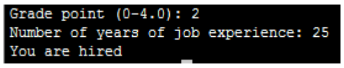
```
    if ((Boolean expression) or (Boolean expression)):
        body
```

- **Name of the online example:** `5if_or_hiring.py`
  - Learning objective of example: applying logical OR (at least one Boolean expression must evaluate to true for compound expression to be true).

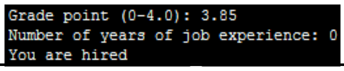
```
gpa = float(input("Grade point (0-4.0): "))
yearsJobExperience = int(input("Number of years of job
 experience: "))
if ((gpa > 3.7) or (yearsJobExperience > 5)):
    print("You are hired")
else:
    print("Insufficient qualifications")
```



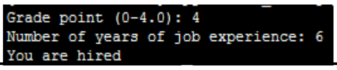
```
Grade point (0-4.0): 2
Number of years of job experience: 0
Insufficient qualifications
```



```
Grade point (0-4.0): 2
Number of years of job experience: 25
You are hired
```



```
Grade point (0-4.0): 3.85
Number of years of job experience: 0
You are hired
```



```
Grade point (0-4.0): 4
Number of years of job experience: 6
You are hired
```

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The "NOT" Operator

- **Format:**

```
   if not (Boolean expression):
       body
```

- **Name of the online example:** `6if_not.py`
  - Learning objective of example: when an action (IF-body) is applied when a condition is not met.
  - (Alternatives to using Not can sometimes be implemented using the inequality operator '!=')

```
SYSTEM_PASSWORD = "password123"
userPassword = input("Password: ")
if not (userPassword == SYSTEM_PASSWORD):
    print("Using logical NOT-operator: Wrong password")
```

James Tam

Quick Summary: Using Logic With Branching

- Use multiple expressions when multiple questions must be asked and the result of expressions are related:
  - AND (strict: **all must apply**):
    - All Boolean expressions must evaluate to true before the entire expression is true.
    - If any expression is false then whole expression evaluates to false.
  - OR (less restrictive: **at least one must apply**):
    - If any Boolean expression evaluates to true then the entire expression evaluates to true.
    - All Boolean expressions must evaluate to false before the entire expression is false.
- Not:
  - Negates or **reverses the logic** of a Boolean expression
  - May sometimes be replaced by the use of an inequality operator

James Tam

Nesting

- Nesting refers to an item that is "inside of" (or "nested in") some other item.
- Nested branches: an '**IF-branch' that is inside of another** 'IF-branch'
  - The nested branch is only checked if the first branch's Boolean expression evaluates to true.
  - Example (assume that the respondent previously indicated the birthplace was an Alberta city).
  - **Select the AB city in which you were born**
    1. Airdrie
    2. Calgary
    3. Edmonton

    Only when the user specifies the residence as Alberta does the program ask for which Alberta city is the residence
    - The prompt for which Alberta city is nested within (only asked) within a positive response indicating Alberta is the province.
    - Is province Alberta? Yes province is Alberta
      - Which Alberta city?

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Recognizing When Nesting Is Needed

- **Scenario 1 (IF inside of another IF, other scenarios are described in the next section)**: A second question is asked if a first question answers true:
  - Example (evaluating eligibility for social assistance): If the person's income is below a certain amount then check **if it's true the applicant is a Canadian citizen**.
  - Type of nesting: an IF-branch nested inside of another IF-branch
  - **Basic structure**

```
If (Boolean):
    If (Boolean):
        ...
```

  - **Example**

```
- If (Income less than cut off):
      If (Canadian citizen?):
          Receive social assistance
```

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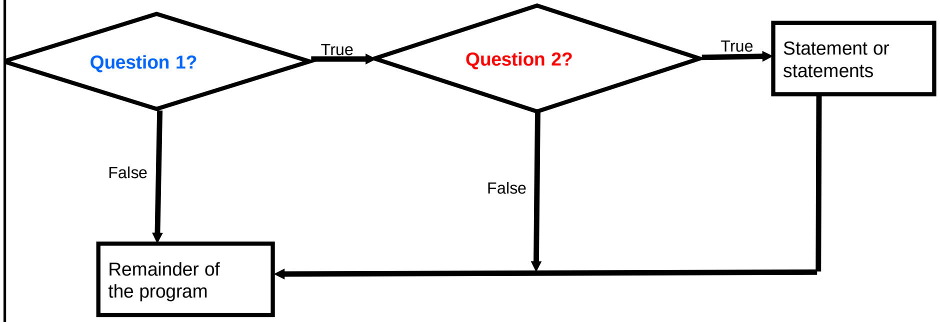
Nested Decision Making: Flowchart

- Decision making is dependent.
- The **first decision** must evaluate to true ("**gate keeper**") before successive decisions are even considered for evaluation.



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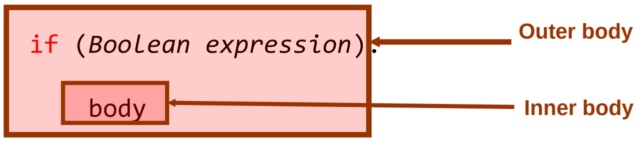
Nested Decision Making: Code Like (Pseudo-Code) Representation

- One **decision is made inside another**.
- **Outer decisions** must evaluate to true before inner decisions are even considered for evaluation.
- **Format:**

```
    if (Boolean expression):
```



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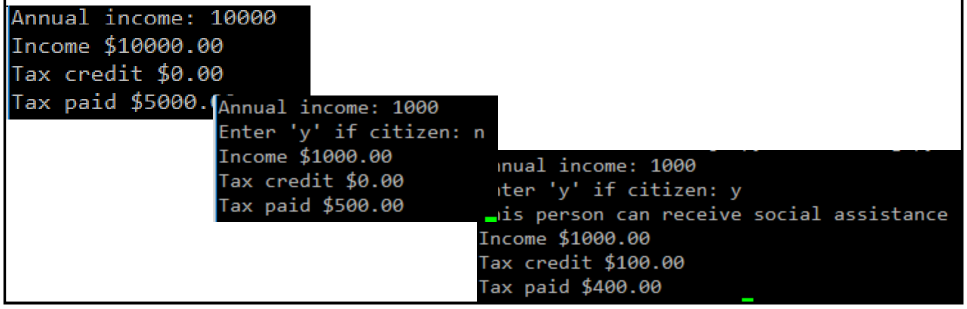
Nested Decision Making: Illustrative Example

- **File containing the full example:** `7nesting.py`
  - Learning objective of example: specifying an outer/initial gatekeeper condition for other conditions.

```
if (income < 10000):
    if (citizen == 'y'):
        print("This person can receive social assistance")
        taxCredit = 100
tax = (income * TAX_RATE) - taxCredit
```



```
Annual income: 10000
Income $10000.00
Tax credit $0.00
Tax paid $5000.
```

```
Annual income: 1000
Enter 'y' if citizen: n
Income $1000.00
Tax credit $0.00
Tax paid $500.00
```

```
nual income: 1000
ter 'y' if citizen: y
is person can receive social assistance
Income $1000.00
Tax credit $100.00
Tax paid $400.00
```

Decision-Making With Multiple Alternatives/Questions

- IF (single question)
  - Checks a condition and executes a body if the condition is true
- IF-ELSE (single question)
  - Checks a condition and executes one body of code if the condition is true and another body if the condition is false
- Approaches for multiple (two or more) questions
  - **Multiple IFs**
  - **IF-ELIF-ELSE**

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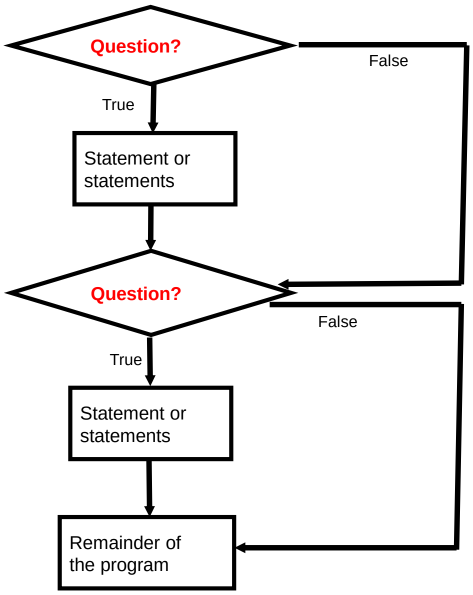
Decision Making With Multiple Ifs



Notice that the 'Ifs' that come later are always evaluated regardless of what earlier 'Ifs' evaluate to.

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Multiple Ifs: Non-Exclusive Conditions

- Any, all or none of the conditions may be true (independent)
  - Alternatively worded: 0+ conditions can be true.
- Employ when a series of independent questions will be asked
- **Format:**

```
if (Boolean expression 1):
    body 1
if (Boolean expression 2):
    body 2
         :
statements after the conditions
```

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Multiple Ifs: Non-Exclusive Conditions (Example)

- **Example:**

```
if (ableAge >= 65):
    print("Senior citizen")
if (bakerAge >= 65):
    print("Senior citizen")
if (foxtrotAge >= 65):
    print("Senior citizen")
```

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Multiple `Ifs`: Mutually Exclusive Conditions

- At most *only one* of many (i.e. 0 or 1) conditions can be true
- Can be implemented through multiple `ifs`

Inefficient combination!

- **Example**: The name of the complete online program is: "`8grades_inefficient.py`"
  - Learning objective of example: illustrating how specifying a sequence of independent conditions can be less than optimal when at most only one condition can be true.

```
 if (letter == "A"):
     gpa = 4
if (letter == "B"):
     gpa = 3
if (letter == "C"):
      gpa = 2
if (letter == "D"):
     print("Min pass")
     gpa = 1
if (letter == "F"):
     print ("Failing grade")
     gpa = 0
```

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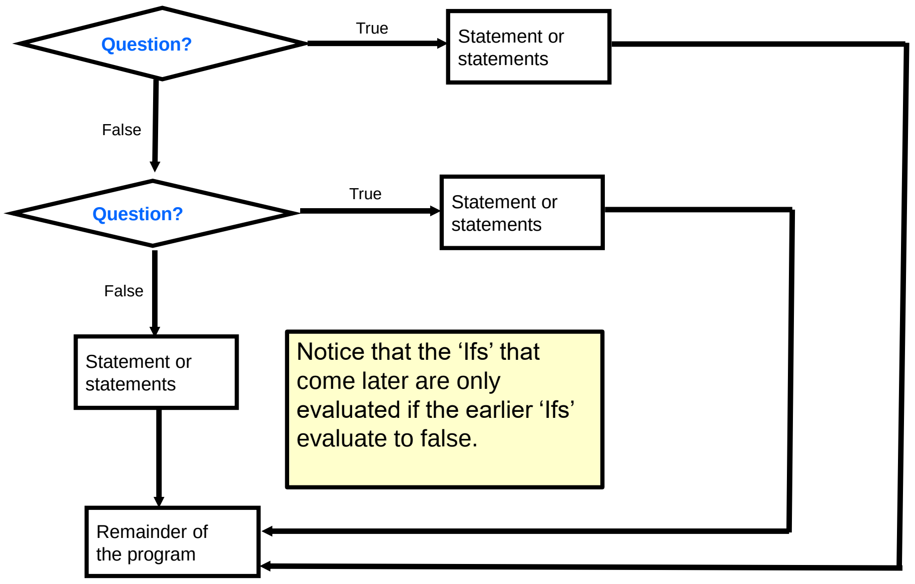
Decision Making With `If-Elif-Else`



Notice that the 'Ifs' that come later are only evaluated if the earlier 'Ifs' evaluate to false.

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Multiple If-Elif-Else: Use With Mutually Exclusive Conditions

- **Format:**

```
if (Boolean expression 1):
    body 1
elif (Boolean expression 2):
    body 2
        :
else
    body n
statements after the conditions
```

Mutually exclusive

- One condition evaluating to true excludes other conditions from being true
- Example: having your current location as 'Calgary' excludes the possibility of the current location as 'Edmonton', 'Toronto', 'Medicine Hat'

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If-Elif-Else: Mutually Exclusive Conditions (Example)

- **Example**: The name of the complete online program is: "9grades_efficient.py"
  - Learning objective of example: illustrating how ELIF is more efficient than multiple IFs when at most 1 condition (0 or 1) can be true.

```
if (letter == "A"):
    gpa = 4
elif (letter == "B"):
    gpa = 3
elif (letter == "C"):
    gpa = 2
elif (letter = "D"):
    gpa = 1
elif (letter = "F"):
    gpa = 0
else:
    print("GPA must be one of 'A', 'B', 'C', 'D' or 'F'")
```

This approach is more efficient when at most only one condition can be true.

Extra main benefit:

The body of the else executes only when all the Boolean expressions are false. (Useful for error checking/handling).

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When To Use `Multiple-Ifs`

- When all conditions must be checked (more than one Boolean expressions for each 'if' can be true).
  - Non-exclusive conditions.
- Example:
  - Some survey questions:
    - When all the questions must be asked
    - The answers to previous questions will not affect the asking of later questions

      E.g.,

      Q1: Is your height above 172 cm?

      Q2: Is your age 18 years or more?

      Q3: Is Canada your country of birth?

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When To Use `If, ElIfs`

- When all conditions may be checked but at most only one Boolean expression can evaluate to true.
  - Exclusive conditions
- Example:
  - Survey questions:
    - When only some of the questions will be asked
    - The answers to previous questions WILL determine if later questions will be asked

      E.g.,

      Q1: Were you born in BC?

      Q2 (ask only if the person answered 'no' to the previous): Were you born in AB?

      Q3 (ask only if the person answered 'no' to the previous questions): Were you born in SK?

      …

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Extra Practice

•(From "Starting out with Python" by Tony Gaddis).

Write a program that prompts the user to enter a number within the range of 1 through 10. The program should display the Roman numeral version of that number. If the number is outside the range of 1 through 10, the program should display an error message. The table on the next screen shows the Roman numerals for the numbers 1 through 10.

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Extra Practice (2)

Number	Roman Numeral
1	I
2	II
3	III
4	IV
5	V
6	VI
7	VII
8	VIII
9	IX
10	X

James Tam

Recap: What Decision Making Mechanisms Are Available /When To Use Them

Mechanism	When To Use
`If`	Evaluate a Boolean expression and execute some code (body) if it's **true**
`If-else`	Evaluate a Boolean expression and execute some code (first body: 'if') if it's **true**, execute alternate code (second body: 'else') if it's **false**.
`Multiple ifs`	Multiple Boolean expressions need to be evaluated with the answer for **each expression being independent** of the answers for **the others (non-exclusive).** Separate instructions (bodies) can be executed for each expression.
`If-elif-else`	Multiple Boolean expressions need to be evaluated but **zero or at most only one of them can be true** (mutually exclusive). Zero bodies or exactly one body will execute. Also it allows for a separate body (`else`-case) to execute when all the `if-elif` Boolean expressions are false.

James Tam

Recap: When To Use Compound And Nested Decision Making

Mechanism	When To Use
Compound decision making	There may have to be more than one condition to be considered before the body can execute. **All expressions must evaluate to true (AND)** or **at least one expression must evaluate to true (OR)**.
Nested decision making	The **outer Boolean expression ("gate keeper") must be true before the inner expression will be evaluated**. (Inner Boolean expression is part of the body of the outer Boolean expression).

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Testing Decision Making Constructs

- Make sure that the body of each decision making mechanism executes when it should.
- Test:

1) Obvious true cases
2) Obvious false cases
3) Boundary cases

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Testing Decisions: An Example

Program name: `10testing_example.py`

Learning objective of example: illustrating an example of the *minimum* number of test cases that should be run for a condition that tests a numeric value.

```
num = int(input("Type in a value for num: "))
if (num >= 0):
    print("Num is non-negative. ")
else:
    print("Num is negative. ")
```

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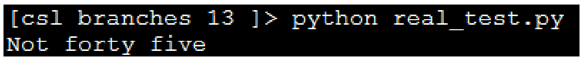
Lesson: Avoid Using A Float When An Integer Will Do

Program name: `11real_test.py`

Learning objective of example: illustrating the imprecise storage mechanism used for floating point variables.

```
num = 1.0 - 0.55
if (num == 0.45):
    print("Forty five")
else:
    print("Not forty five")
```



```
[csl branches 13 ]> python real_test.py
Not forty five
```

- If there is a specific need to handle this issue we will go over ways of mitigating the problem.
- If you're interested then you can look up potential solutions online: search 'epsilon' and floating point representations
- Or you can look at an older version of this course where mitigation measures were covered during the term:
- https://pages.cpsc.ucalgary.ca/~tamj/2021/217P/

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Extra Practice

- (From "Starting out with Python" by Tony Gaddis)

The following code contains several nested if-else statements. Unfortunately it was written without proper alignment and indentation. Rewrite the code and use the proper conventions of alignment and indentation.

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Extra Practice (2)

```
# Grade cut-offs
A_SCORE = 90
B_SCORE = 80
C_SCORE = 70
D_SCORE = 60
```

```
if (score >= A_SCORE):
print("Your grade is A")
else:
if (score >= B_SCORE):
print("Your grade is B")
else:
if (score >= C_SCORE):
print("Your grade is C")
else:
if (score >= D_SCORE):
print("Your grade is D")
else:
print("Your grade is F")
```

Common student question: If there isn't a pre-created solution then how do I know if I "got this right"?

James Tam

Rule Of Thumb: Branches

- Be careful that your earlier cases don't include the later cases if each case is supposed to be handled separately and exclusively.

Example 1 (Wrong)

```
if (num >= 0):
elif (num >= 10):
elif (num >= 100):
```

Example 2 (Right)

```
if (num >= 100):
elif (num >= 10):
elif (num >= 0):
```

James Tam

Extra Practice: Grades

- Write a program that converts percentages to one of the following letter grades: A (90 – 100%), B (80 – 89%), C (70 – 79%), D (60 – 69%), F (0 – 59%).

```
# First approach
if ((percentage <= 100) or (percentage >= 90)):
    letter = 'A'
elif ((percentage <= 89) or (percentage >= 80)):
    letter = 'B'
Etc.

# Second approach
if ((percentage <= 100) and (percentage >= 90)):
    letter = 'A'
elif ((percentage <= 89) and (percentage >= 80)):
    letter = 'B'
Etc.
```

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Decision Making: Checking Matches

- Python provides a quick way of checking for matches within a set.
  - E.g., for a menu driven program the user's response is one of the values in the set of valid responses.

Format:

```
(Strings)
if <string variable> in ("<string1> <string2>...<stringn>"):
     body

(Numeric)
if <numeric variable> in (<number1>, <number2>,...<numbern>):
     body
```

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Decision Making: Checking Matches (2)

Example:

```
(String):
if "the" in ("thetheretheir"):
    print("the is a sub-string of thetheretheir ")
else:
    print("not sub-string")

answer = input("Selection (any but 1, 2, 7): ")
if answer in ("one two seven"):
    print("selection taken")
else:
    print("selection available")

(Numeric):
if num in (1, 2, 3):
    print("in set")
```

James Tam

Checking Matches: Another Example

- **Complete example**: `12inOperator.py`
- Learning objective of example: illustrating the use of the `IF-IN` operator in conjunction with strings as well showing the use of the NOT operator.

```
print("Menu options")
print("(a)dd a new player to the game")
print("(r)emove a player from the game")
print("(m)odify player")
print("(q)uit game")
selection = input("Enter your selection: ")
if selection not in ("a", "A", "r",  "R", "m", "M", "q", "Q"):
    print("Please enter one of 'a', 'r', 'm' or 'q' ")
```

James Tam

After This Section You Should Now Know

- How to use the logical operators in conjunction with branching:
  - AND
  - OR
  - NOT
- How to test decision making constructs
- When/how to employ multiple `IF` structures
- When/how to employ an `IF-ELIF` structure
- When to employ nested `IF` structures
- How to trace nested `IF` structures
- The `IF-IN` operator

James Tam

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