

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 they are required with other languages

•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
```

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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")
```

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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

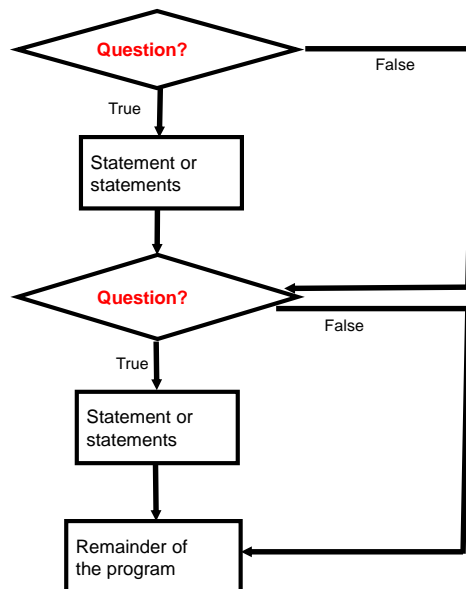
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Decision-Making With Multiple Alternatives/Questions

- 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")
```

Use multiple Ifs for
non-exclusive
conditions:
independent branches

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Multiple Ifs: Mutually Exclusive¹ 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:

"7grades_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.

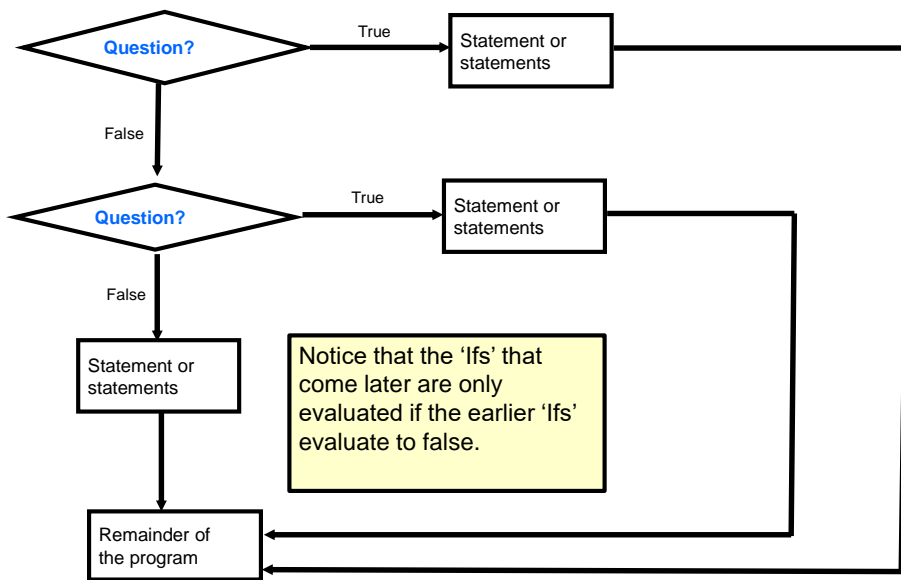
```
if (letter == "A"):  
    gpa = 4  
if (letter == "B"):  
    gpa = 3  
if (letter == "C"):  
    gpa = 2  
if (letter == "D"):  
    print("Min pass")  
    gpa = 1  
if (letter == "F"):  
    print("Failing grade")  
    gpa = 0
```

DO NOT use multiple Ifs
for mutually exclusive
conditions:
interdependent branches
i.e., Cannot easily
implement a "none of the
above" case.

¹ One condition evaluating to true excludes other conditions from being true (no need to check)

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Decision Making With If-Elif-Else



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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:

"8grades_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'")
```

Use an If-elif structure for mutually exclusive conditions: interdependent branches

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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"Deal Breakers"

- A term that is used in everyday usage:
 - Business negotiations
 - "someone or something that prevents a deal or arrangement from being reached or fulfilled" ¹
 - Job applications (for both the person applying for the job and for the organization doing the hiring)
 - Personal relationships ('dating')
 - "a reason for rejecting someone..."¹
 - Top 10 relationship deal breakers (not required reading for developing your programming skills but seeing everyday examples of actual/common deal breakers can help if you are not familiar with the term "deal breaker")
 - <https://www.psychologytoday.com/us/blog/close-encounters/201510/the-top-10-relationship-deal-breakers>

¹ Definitions from: <https://www.merriam-webster.com/dictionary/deal%20breaker>

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Programming Deal Breakers

- They are a condition or conditions that must be met.
- If the deal breaker condition/conditions are not met then other conditions are not relevant.
- Consider this in terms of personal relationships: if the deal breaker condition(s) is not met then all of the other characteristics of that person don't matter.
- Deal breakers can be implemented in the form of nesting (or nested branches/conditions).

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Nesting In Programming (~“Deal Breaker”)

- Nesting refers to an item that is “inside of” (or “nested in”) some other item.
 - E.g. `(2+2)*3, int(input("Age: "))`
- Nested branches: an ‘**IF-branch**’ that is inside of another ‘IF-branch’
 - 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

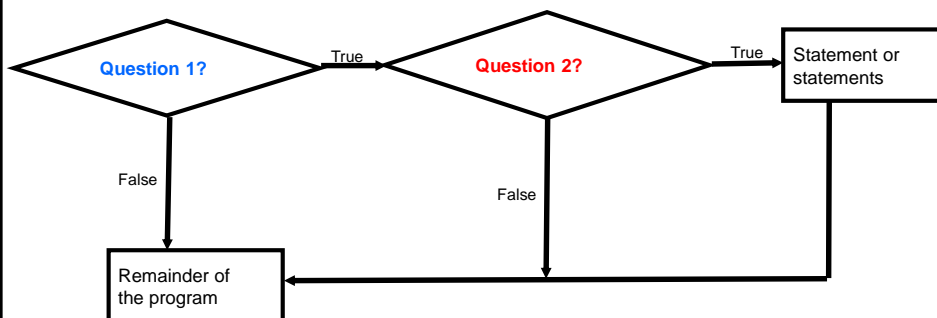
- **Scenario 1 (IF inside of another IF, other scenarios are described in the next section):** A second question is asked if a only if the first question answers true:
 - Example (evaluating eligibility for social assistance): If the person's income is below a certain amount then check **if it's true 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 ("**deal breaker**" / "**gate keeper**") before **successive decisions** are even considered for evaluation.



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New Term: Pseudo Code

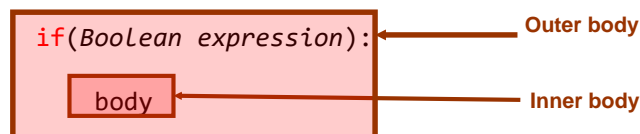
- A high level solution or algorithm that is not specified in a programming language.
 - “Sort of code” (expressions that look like actual program code but aren’t as bound by syntax requirements).
- Instead English-like statements are used.
 - “A high-level description of the actions of a program or algorithm, using a mixture of English and informal programming language syntax” – Python for Everyone (Horstmann, Necaie)
- It can be specified at different levels of detail (very general to very specific).
- There is not a hard and fast rule for the detail level.
- Benefits: it allows the programmer to focus on the solution without spending a lot of time worrying about details such as syntax.

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Nested Decision Making

- 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: 9nesting.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 $5000.00
```

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

```
Annual income: 1000  
Enter 'y' if citizen: y  
This person can receive social assistance  
Income $1000.00  
Tax credit $100.00  
Tax paid $400.00
```

Simple Text Formatting

- There's more than one way to do this with python e.g. using "format specifiers" (this example), using the "format" method etc.

- The previous example used a **format specifier to show 2 places of precision** would be displayed for the floating point values.

```
print("Income $%.2f" %income)  
print("Tax credit $%.2f" %taxCredit)  
print("Tax paid $%.2f" %tax)
```

```
#income, taxCredit, tax: three variables initialized earlier.
```

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Which Approach To Use For Formatting?

- Unless otherwise told you can use any approach on an assignment.
 - But you should be familiar with the one approach taught (format specifier) for the examinations.
- The format specifier is an older approach implemented in python but something similar is employed with other languages:
 - **C example:** `printf("Income: %.2f", income);`
 - **Java example:** `System.out.printf("Income %f", 0.2income);`
- The newest approach in python involves the use of “f-strings”.

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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.

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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. ")
```

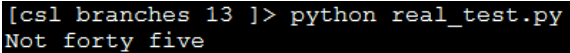
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Lesson: Avoid Using A Float When An Integer Will Do

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")
```



- 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 another older version of another course where mitigation measures were taught during the term:
- <https://pages.cpsc.ucalgary.ca/~tamj/2021/217P/> (Branching Part II)

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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

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

```
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")
```

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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):
```

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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' ")
```

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Exercise: Nesting

- Student exercise (to do on your own for extra practice):
determine the output of the following program.

```
num1 = int(input("First number: "))
num2 = int(input("Second number: "))
num3 = int(input("Third number: "))
print("1",end="")
if(num1 > 0):
    print("2",end="")
    if((num2 > 0) or (num3 < 0)):
        print("3",end="")
    else:
        print("4",end="")
print("5",end="")
```

Determine
output when the
user enters:

0,0,0
1,2,3

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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

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