Topic 4: Decisions

Recommended Readings

- Strongly Recommended Exercises
  - The Python Workbook: 38, 39, 45, and 56
- Recommended Exercises
  - The Python Workbook: 36, 43, 47, 49, 57 and 58
- Recommended Readings
  - Starting Out with Python
    - Chapter 4 (2nd Ed.) / Chapter 3 (3rd Ed. and 4th Ed.)

Review

- What kinds of statements have we seen so far?
  - Assignment statements
  - Input statements
  - Output statements

- These are generally necessary, but not sufficient, to solve “interesting” problems

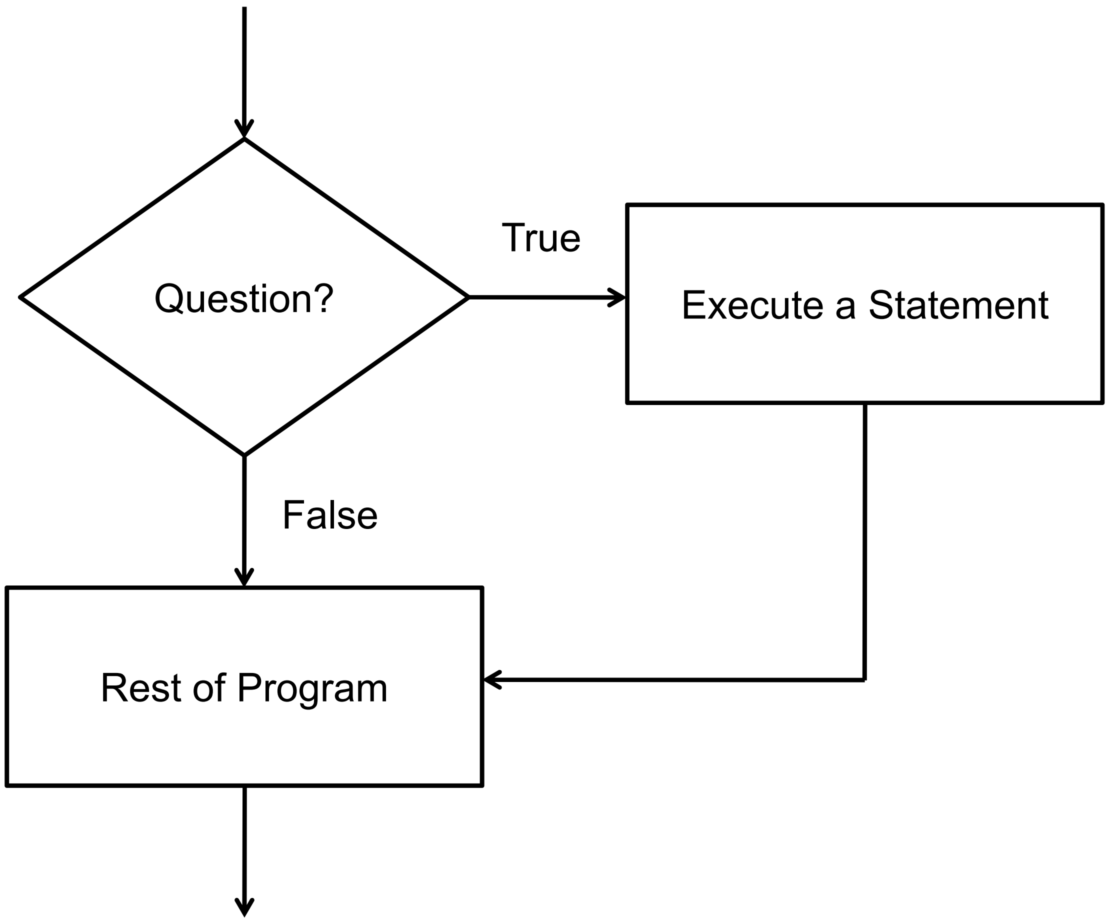
Example

- Determine the state of gold when it is at a given temperature
  - Gold is solid when the temperature < 1064.43 degrees
  - Gold is liquid when the temperature is between 1064.43 and 2807.00 degrees
  - Otherwise gold is gaseous

If Statements

- If statements
  - Permit or prevent another statement from executing
  - Start with the word `if`
  - Allow us to test anything that can be determined to be true or false
- General Form:
  - `if` condition`:`
    body

Decisions



Condition

- The condition portion of an if statement must be a Boolean result
  - True or False
  - Can be
    - Value of a variable
    - Result of a function
    - Result of a relational operator
    - …

Relational Operators

- Relational operators compare two values
  - Result will be true or false
  - Operators:

<	less than
>	greater than
<=	less than or equal
>=	greater than or equal
==	equal
!=	not equal

Relational Operations

- Values tested can be
  - Variables
  - Literals
  - Results from functions
  - Expressions
  - …
- Types tested can be
  - Integers, Floats, Booleans, Strings
  - …

Gold Example

Liquid Gold?

- How do we test whether the gold is liquid?
  - temperature must be greater than 1064.43
  - temperature must be less than 2807.00

Boolean Logic

- A system of logical values and operators
  - Values
    - True, False
  - Operators
    - And
    - Or
    - Not
    - Xor
    - …
  - Used to form complex conditions

Boolean Logic

- Truth tables describe the behavior of logical operators

Input(s)	Output
Input Values	Output Values

A	not A
0	
1	

- The not operator flips the value of its input

Boolean Logic

- And Operator
  - Takes two inputs
  - Produces one output
  - Output is True if and only if both inputs are true

A	B	A and B
0	0	
0	1	
1	0	
1	1	

Boolean Logic

- Or Operator
  - Takes two inputs
  - Produces one output
  - Output is True if one input is true (or both inputs are true)

A	B	A or B
0	0	
0	1	
1	0	
1	1	

Boolean Logic

- Exclusive Or Operator
  - Takes two inputs
  - Produces one output
  - Output is True if exactly one input is true

A	B	A xor B
0	0	
0	1	
1	0	
1	1	

Boolean Logic

- Python doesn’t include an xor operator
- What logical expression can we use to achieve the same result?

Boolean Logic

- When is not(A and B) true?

A	B	A and B	not (A and B)
0	0		
0	1		
1	0		
1	1		

- We call this operation Nand

Boolean Logic

- When is not(A or B) true?

A	B	A or B	not (A or B)
0	0		
0	1		
1	0		
1	1		

- We call this operation Nor

Boolean Logic

- Example:
  - Construct a truth table for A and (B or not C):

Boolean Logic

- Boolean logic is the basis for computation in modern computers
  - Circuits can implement logical operations
  - Arithmetic operations can be built up from logical operations
  - Memory can be constructed by including feedback loops in the circuits

Gold Example

Precedence

- Relational and logical operators have lower precedence than mathematical operators
  - Mathematical Operators
  - Relational Operators
  - not
  - and
  - or
  - assignment

Precedence

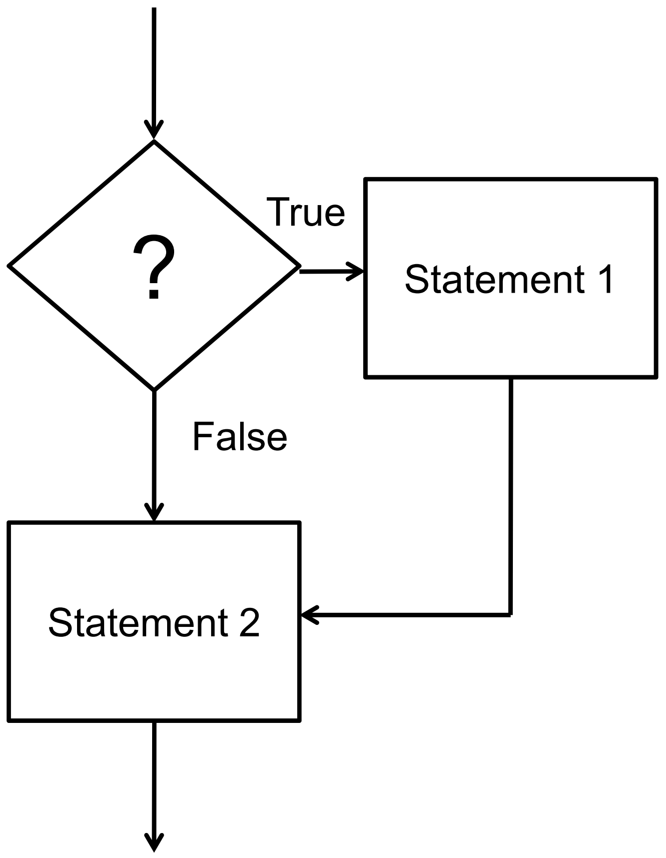
- Consider the following expressions:
  - w = 3 + 4 * 5 < 3 * 4 + 5 or 1 / 2 != 0

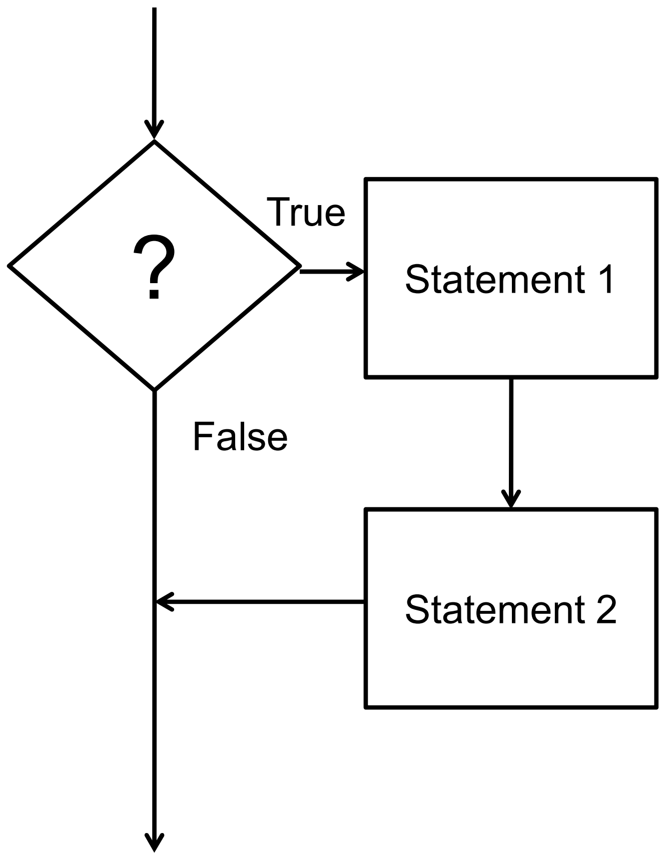
  -
    ```
    a = False
    b = False
    c = True
    x = 5
    if a or b and c or 1 < x and x < 10:
        print(x)
    ```

If Statement Conditions

- Don’t make the condition unnecessarily complex
  - `if x:` is equivalent to `if x == True:`
  - `if not x:` is equivalent to `if x == False:`

Compound Statements





Compound Statements

- The body of an if statement
  - May contain one statement
  - May contain many statements
- How do we know which statements are included in the body?
  - Body is determined by indenting
  - Body ends with the next line that is indented the same amount as the `if`

Compound Statements

```
x = int(input())
print("A")
if x < 0:
    print("B")
    print("C")
print("D")
print("E")
print("F")
```

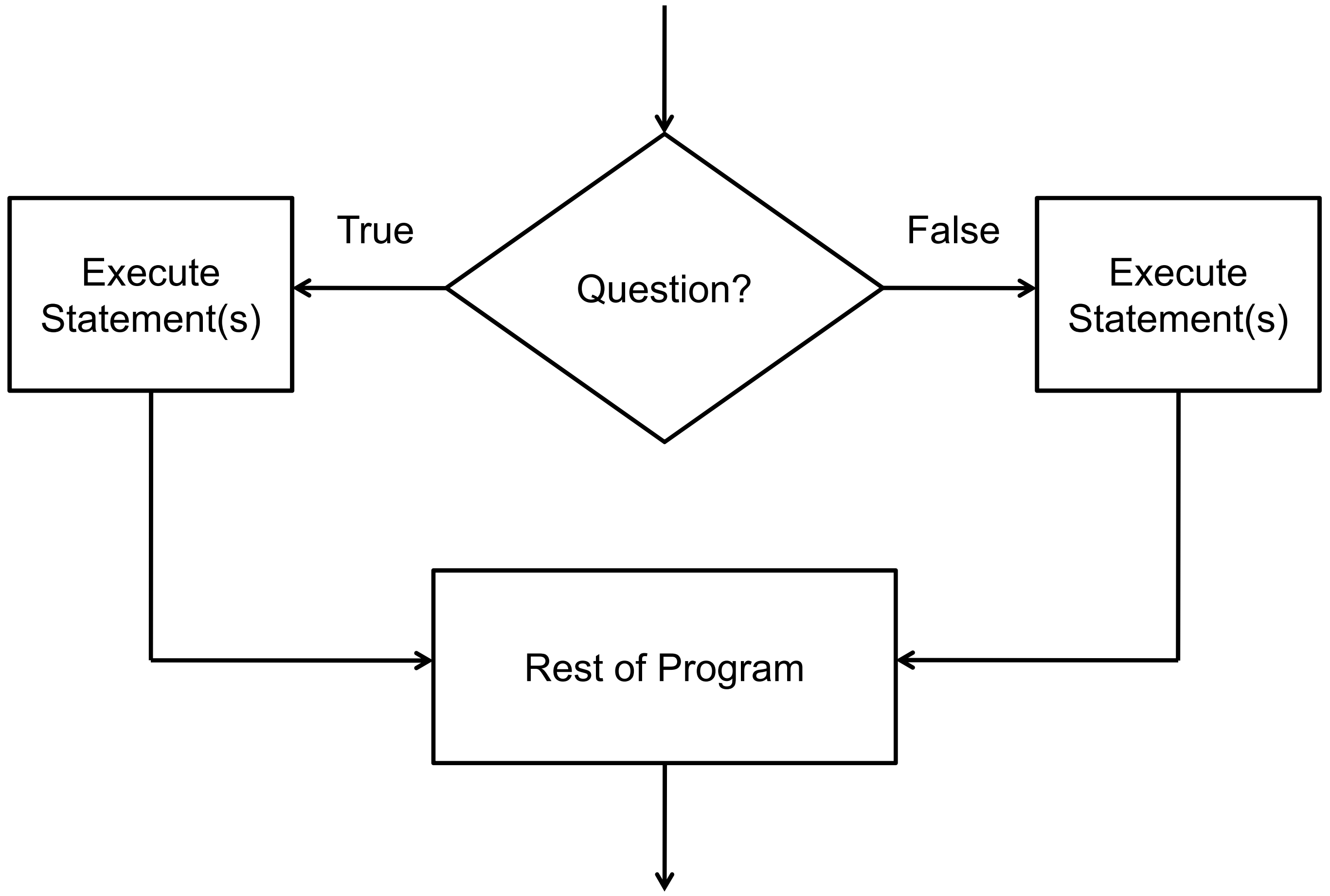
If-Then-Else

- What if we have a condition
  - want to do something when the condition is true
  - want to do something else when the condition is false

```
if condition:
  print("Doing something...")

if not condition:
  print("Doing something else...")
```

If-Then-Else


True
Question?
False
Execute Statement(s)
Execute Statement(s)
Rest of Program

Gold Example

Nested If Statements

- An if statement can reside in the body of another if statement
  - How do we expand our program so that it handles all three states?
    - Gold is solid when the temperature < 1064.43 degrees
    - Gold is liquid when the temperature is between 1064.43 and 2807.00 degrees
    - Otherwise gold is gaseous

Gold Example

If-Then-Elif-Else

- Allows exactly one of several options to execute
  - Conditions are tested sequentially until one evaluates to True
  - Body of the condition is executed
  - No further conditions are considered once a condition that evaluates to True is found

Gold Example

Multiple Elif Example

Tax Example

- What if we want to write a program that calculates federal income tax
  - Tax payable is
    - 15% of income up to $45,916
    - 20.5% of income from $45,916 to $91,831
    - 26% of income from $91,831 to $142,353
    - 29% of income from $142,353 to $202,800
    - 33% of income above $202,800

Tax Example

Testing

- The process of executing a program in an attempt to locate bugs
  - How many times do we need to run the program?
  - What can’t testing do?

Testing

- Black-box testing
  - Test the program without looking at the source code
  - Test are generally functional / behavioural
- White-box testing
  - Design test cases for the program by looking at its source code
  - Tests are generally structural

White Box Test Coverage

- How thoroughly do the cases test the code?
  - Condition Coverage: Every decision point in the program is executed
  - Statement Coverage: Every statement in the program is executed
  - Path Coverage: Every possible path through the program is executed

Testing Example

The Dangers of Floating Point Numbers

- Floating point numbers approximate real numbers
  - Can cause problems when testing for equality

Wrapping Up

- Three kinds of decision statements
  - If statement
  - If-Else statement
  - If-Elif-…-Elif-Else statement
- Each makes it possible to change the flow of control through the program

Wrapping Up

- More complex control flow requires
  - Additional design
  - Additional testing
    - Black box
    - White box

Where Are We Going?

- What if we want to do something several times?
  - A fixed number of times?
  - A number of times entered by the user?
  - Keep doing something until a specific event occurs?
- Next Up: Repetition