

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.)

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

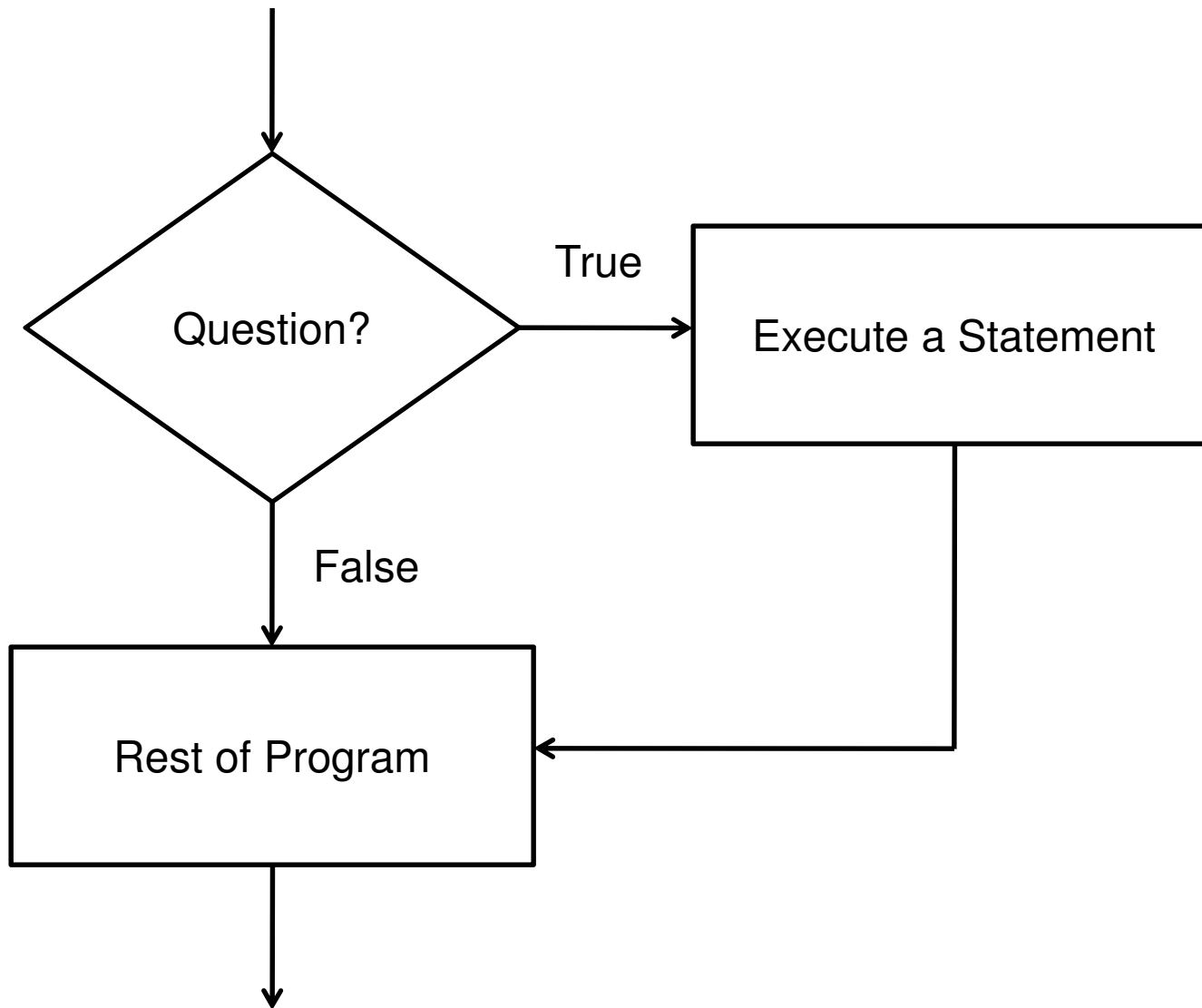
Example

- 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 $\text{not}(A \text{ and } B)$ 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 $\text{not}(A \text{ or } B)$ 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 $(B \text{ or not } C)$:

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 $1 / 2 != 0$

– $a = \text{False}$

$b = \text{False}$

$c = \text{True}$

$x = 5$

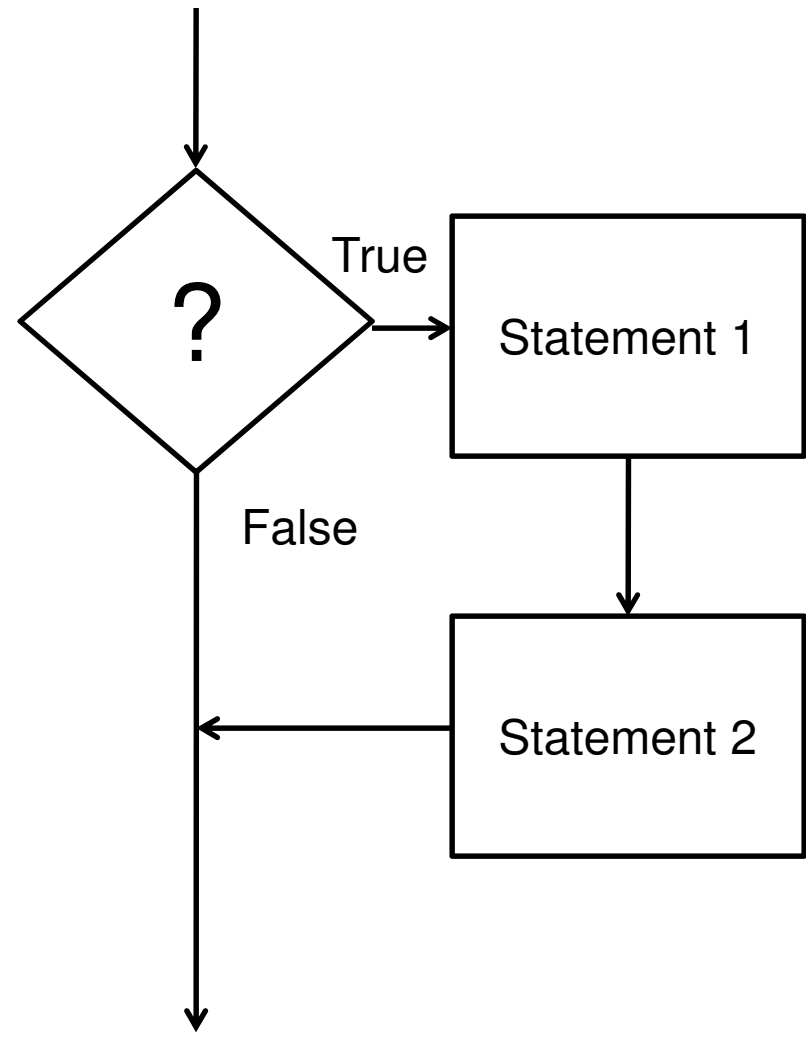
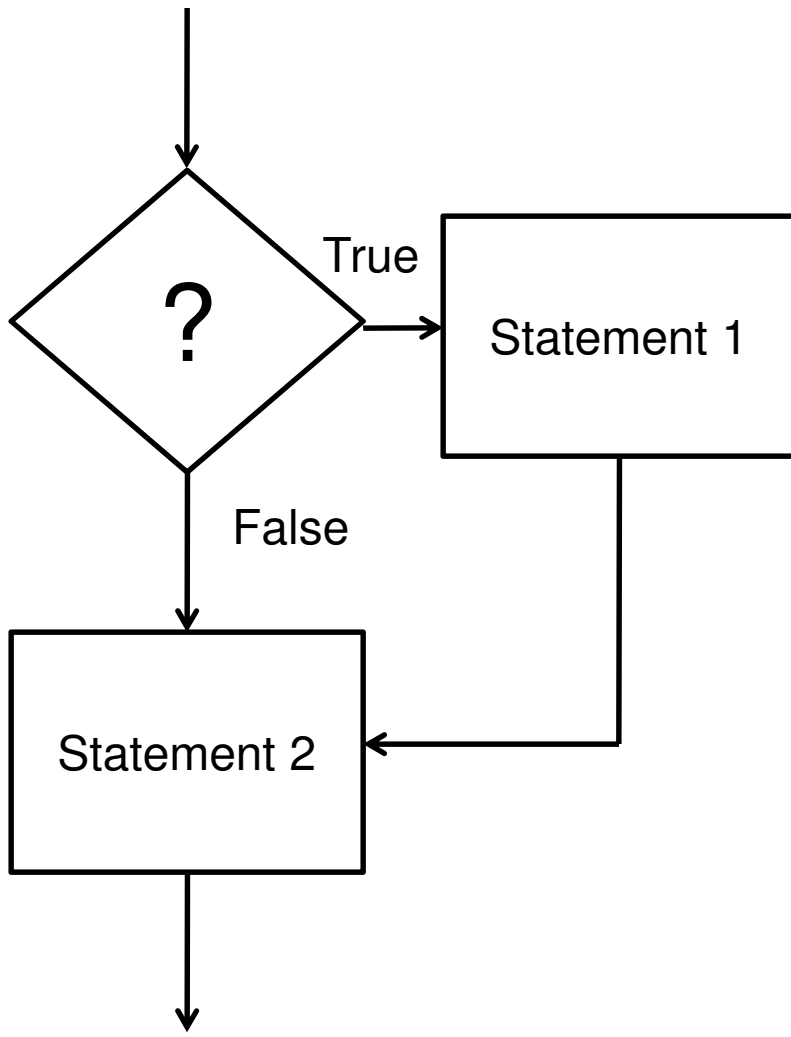
if a or b and c or $1 < x$ and $x < 10$:

$\text{print}(x)$

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")
```

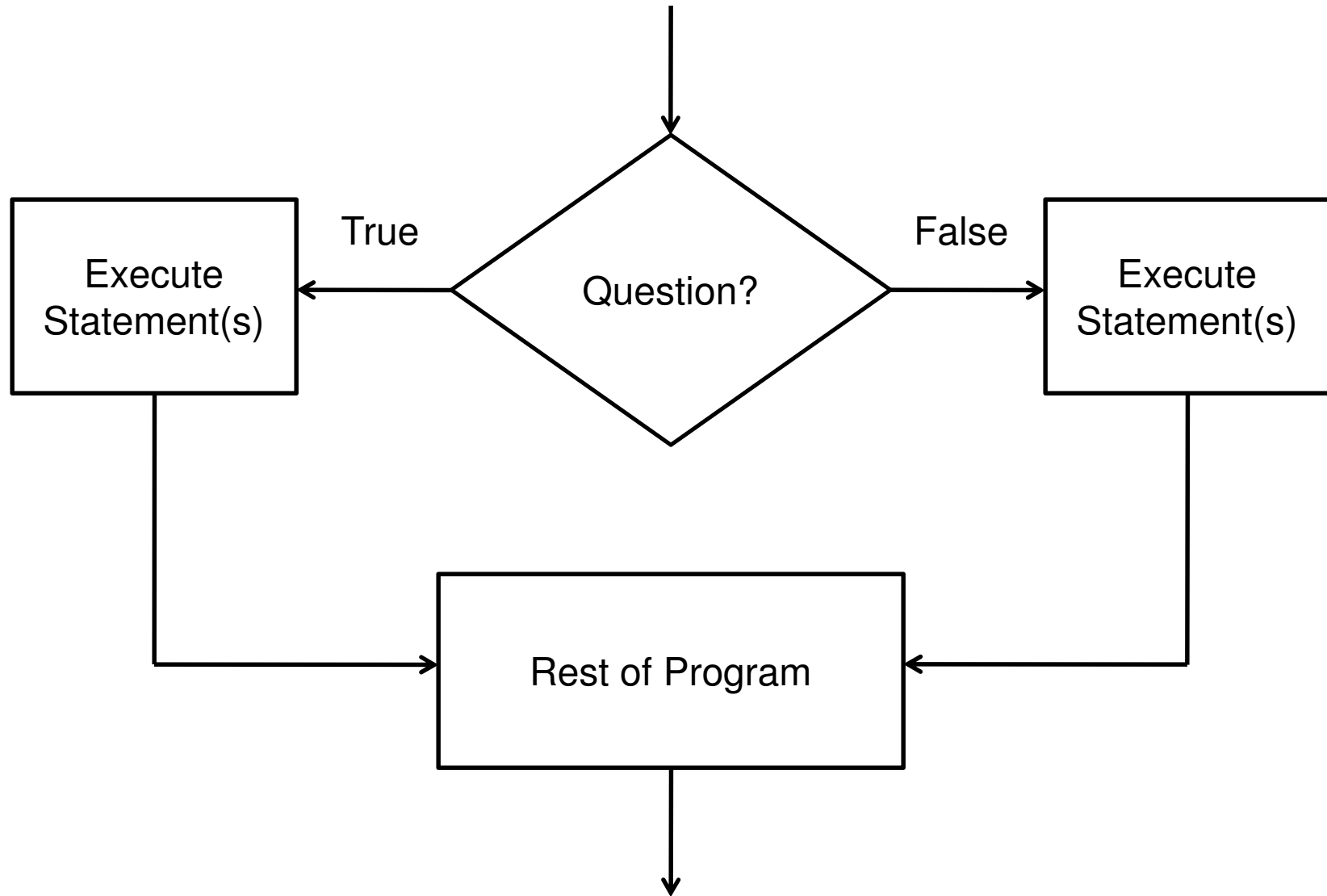
If-Then-Else

- 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



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 \$43,561
 - 22% of income from \$43,561 to \$87,123
 - 26% of income from \$87,123 to \$135,054
 - 29% of income above \$135,054

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
 - Tests 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