Goals

- To implement decisions using the if statement
- To compare integers, floating-point numbers, and Strings
- To write statements using the Boolean data type
- To develop strategies for testing your programs
- To validate user input

In this chapter, you will learn how to program simple and complex decisions. You will apply what you learn to the task of checking user input.

Contents

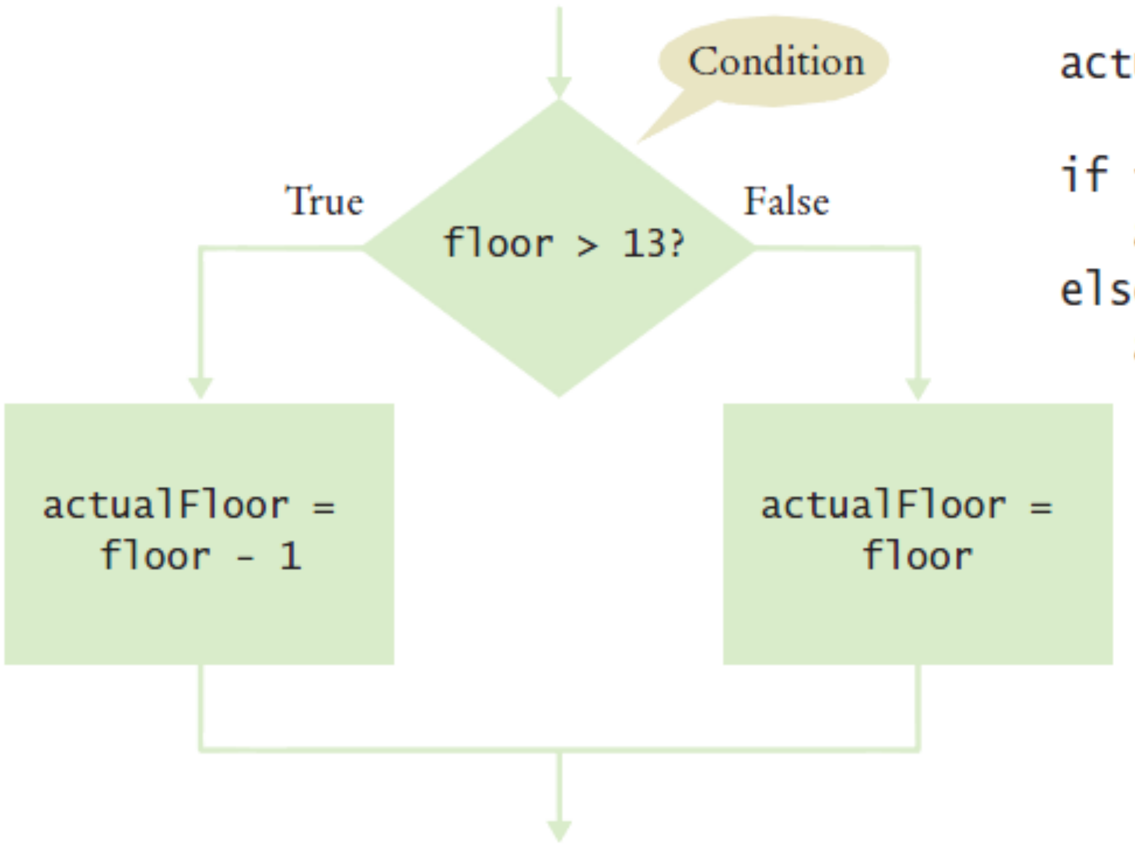
The `if` Statement

- A computer program often needs to make decisions based on input, or circumstances
- For example, buildings often 'skip' the 13th floor, and elevators should too
  - The 14th floor is really the 13th floor
  - So every floor above 12 is really 'floor - 1'
    - If floor > 12, Actual floor = floor - 1
- The two keywords of the if statement are:
  - `if`
  - `else`

> The `if` statement allows a program to carry out different actions depending on the nature of the data to be processed.

Flowchart of the `if` Statement

- One of the two branches is executed once
  - True (`if`) branch or False (`else`) branch

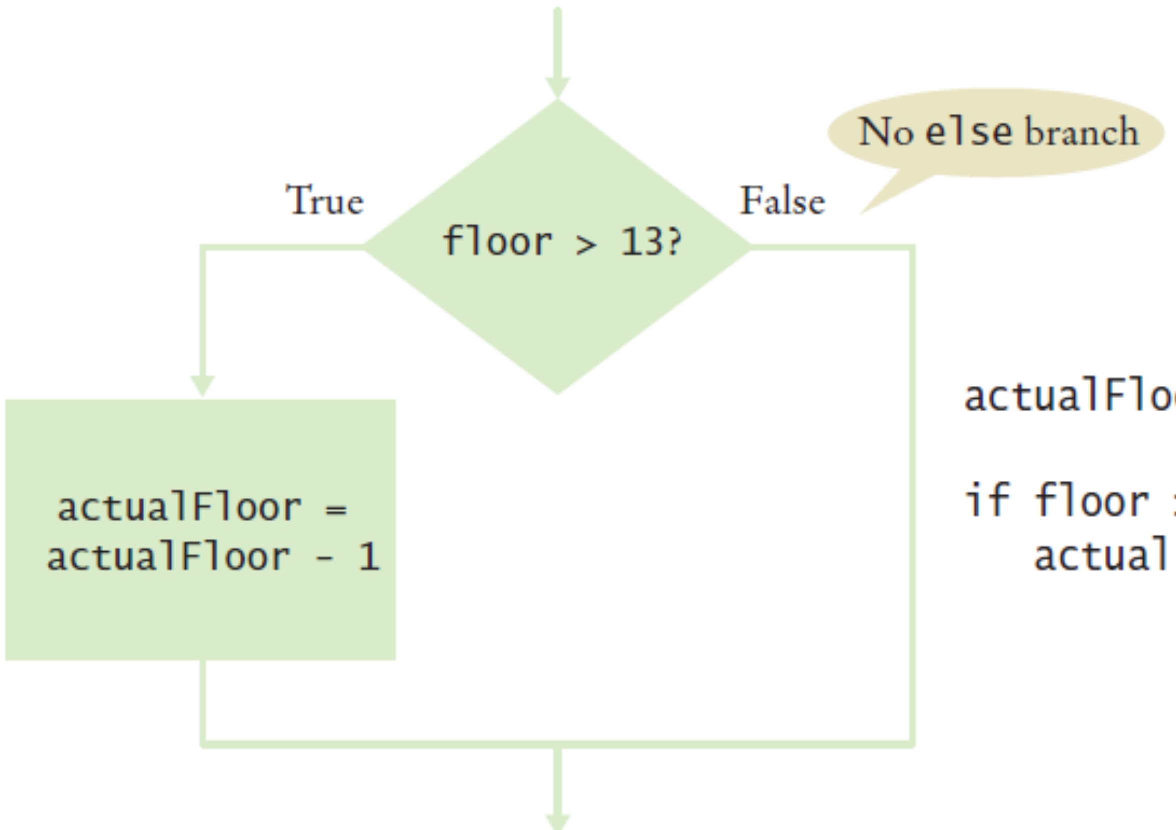



```
actualFloor = 0

if floor > 13 :
    actualFloor = floor - 1
else :
    actualFloor = floor
```

Flowchart with only a True Branch

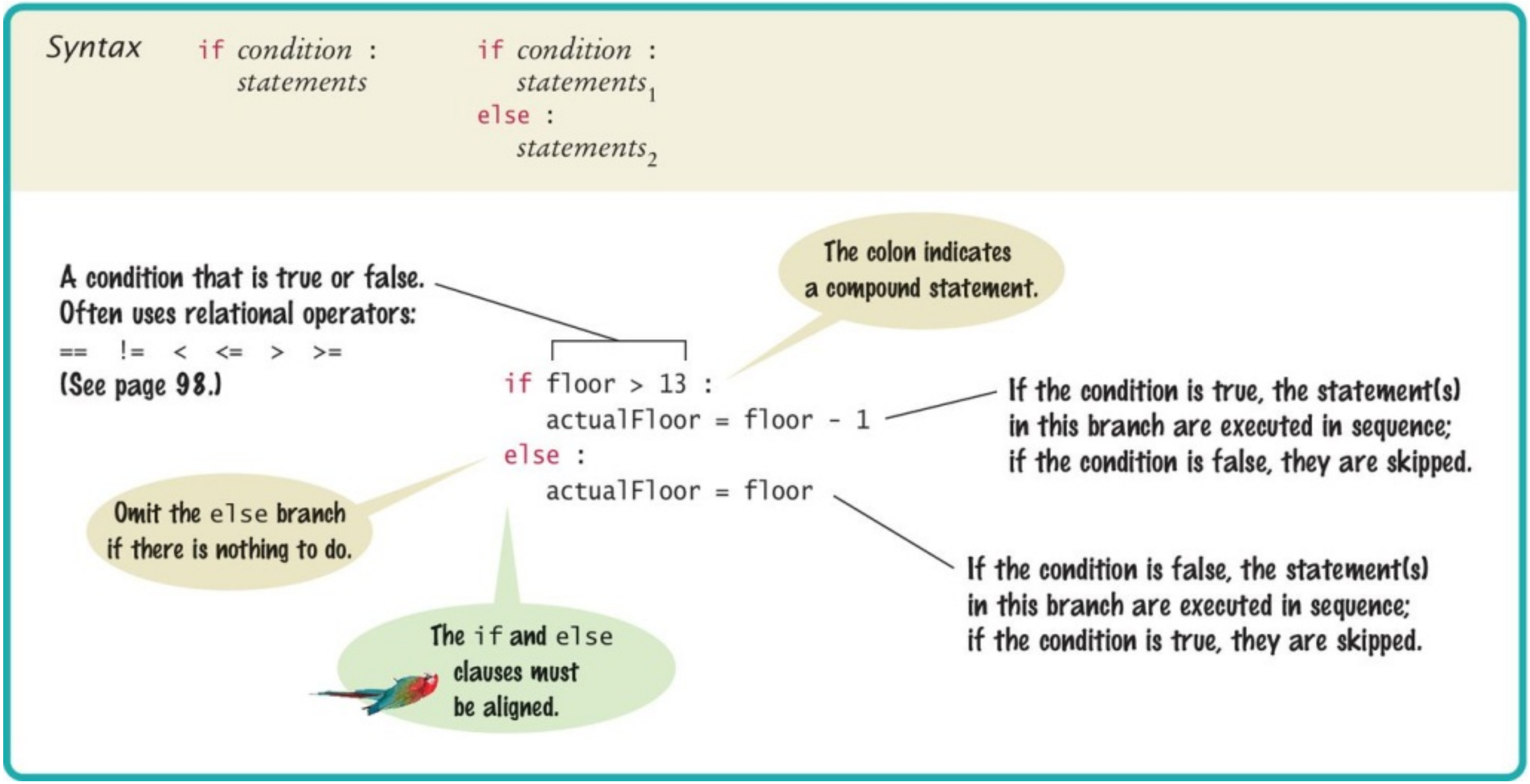
- An `if` statement may not need a 'False' (`else`) branch




```
actualFloor = floor

if floor > 13 :
   actualFloor = actualFloor – 1
```

Syntax 3.1: The `if` Statement



Elevatorsim.py

```
##
#   This program simulates an elevator panel that skips the 13th floor.
#

# Obtain the floor number from the user as an integer.
floor = int(input("Floor: "))

# Adjust floor if necessary.
if floor > 13 :
    actualFloor = floor - 1
else :
    actualFloor = floor

# Print the result.
print("The elevator will travel to the actual floor", actualFloor)
```

Program Run

```
Floor: 20
The elevator will travel to the actual floor 19
```

Our First Example

- Open the file:
  - elevatorsim.py
  - This is a slightly modified program
- Run the program
  - Try a value that is less that 13
    - What is the result?
  - Run the program again with a value that is greater than 13
    - What is the result?
- What happens if you enter 13?

Our First Example (2)

- Revised Problem Statement (1):
  - Check the input entered by the user:
  - If the input is 13, set the value to 14 and print a message
  - Modify the elevatorsim program to test the input

The relational operator for equal is “==“

- Modified Problem Statement (2)
  - In some countries the number 14 is considered unlucky.
  - What is the revised algorithm?
  - Modify the elevatorsim program to “skip” both the 13^{th} and 14^{th} floor

Compound Statements

- Some constructs in Python are **compound statements**.
- **compound statements** span multiple lines and consist of a *header* and a statement block

The if statement is an example of a compound statement

- Compound statements require a colon ":" at the end of the header.
- The statement block is a group of one or more statements, *all indented to the same column*
- The statement block ***starts on the line after the header*** and ***ends at the first statement indented less than the first statement in the block***

If you use Wing; Wing properly indents the statement block.

at the end of the block enter a blank line and wing will shift back to the first column in the current block

Compound Statements

- Statement blocks can be nested inside other types of blocks (we will learn about more blocks later)
- Statement blocks signal that one or more statements are part of a given compound statement
- In the case of the if construct the statement block specifies:
  - The instructions that are executed if the condition is true
  - Or skipped if the condition is false

Statement blocks are visual cues that allow you to follow the login and flow of a program

Tips on Indenting Blocks

- Let Wing do the indenting for you…

```
if totalSales > 100.0 :
↑  discount = totalSales * 0.05
|  totalSales = totalSales - discount
|  print("You received a discount of $%.2f" % discount)
else :
↑  diff = 100.0 - totalSales
|  if diff < 10.0 :
|  ↑  print("If you were to purchase our item of the day you can receive a 5% discount.")
|  else :
|  ↑  print("You need to spend $%.2f more to receive a 5% discount." % diff)
|  |  ↑
|  |  |
0  1  2  Indentation level
```

This is referred to as "block structured" code. Indenting consistently is not only syntactically required in Python, it also makes code much easier to follow.

A Common Error

- Avoid duplication in branches
- If the same code is duplicated in each branch then move it out of the if statement.

```
if floor > 13 :
   actualFloor = floor - 1
   print("Actual floor:", actualFloor)
else :
   actualFloor = floor
   print("Actual floor:", actualFloor)
```

```
if floor > 13 :
   actualFloor = floor - 1
else :
   actualFloor = floor
print("Actual floor:", actualFloor)
```

The Conditional Operator

- A “shortcut” you may find in existing code
  - It is not used in this book
  - The shortcut notation ***can*** be used anywhere that a value is expected

True branch | Condition | False branch

```
actualFloor = floor - 1 if floor > 13 else floor
```

```
print("Actual floor:", floor - 1 if floor > 13 else floor)
```

Complexity is BAD….

This “shortcut” is difficult to read and a poor programming practice

Relational Operators

- Every if statement has a condition
  - Usually compares two values with an operator

```
if floor > 13 :
  ..
if floor >= 13 :
    ..
if floor < 13 :
    ..
if floor <= 13 :
     ..
if floor == 13 :
    ..
```

Table 1 Relational Operators

Python	Math Notation	Description
>	>	Greater than
>=	≥	Greater than or equal
<	<	Less than
<=	≤	Less than or equal
==	=	Equal
!=	≠	Not equal

Assignment vs. Equality Testing

- Assignment: *makes* something true.

```
floor = 13
```

- Equality testing: *checks* if something is true.

```
if floor == 13 :
```

Comparing Strings

- Checking if two strings are equal

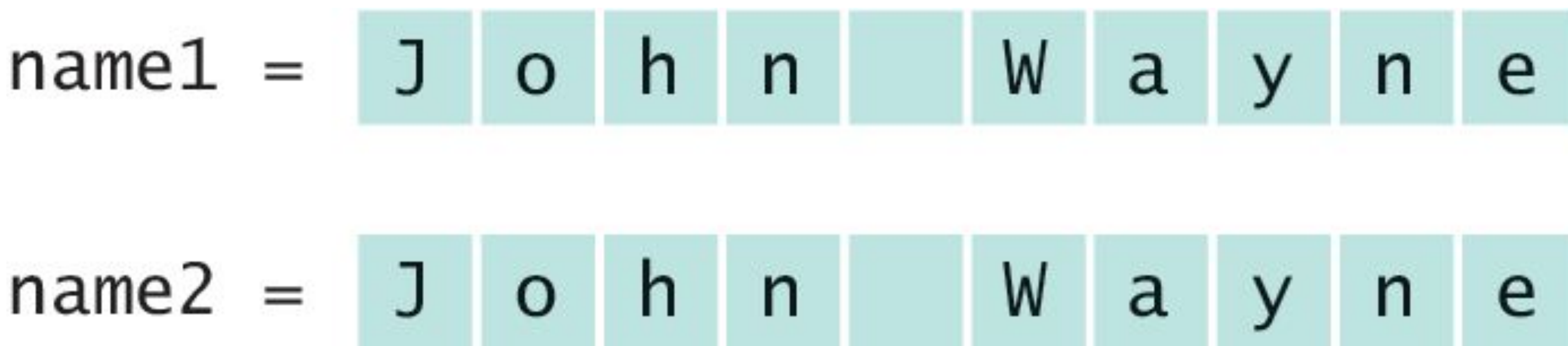
```
if name1 == name2 :
   print("The strings are identical")
```

- Checking if two strings are not equal

```
if name1 != name2 :
   print("The strings are not identical")
```

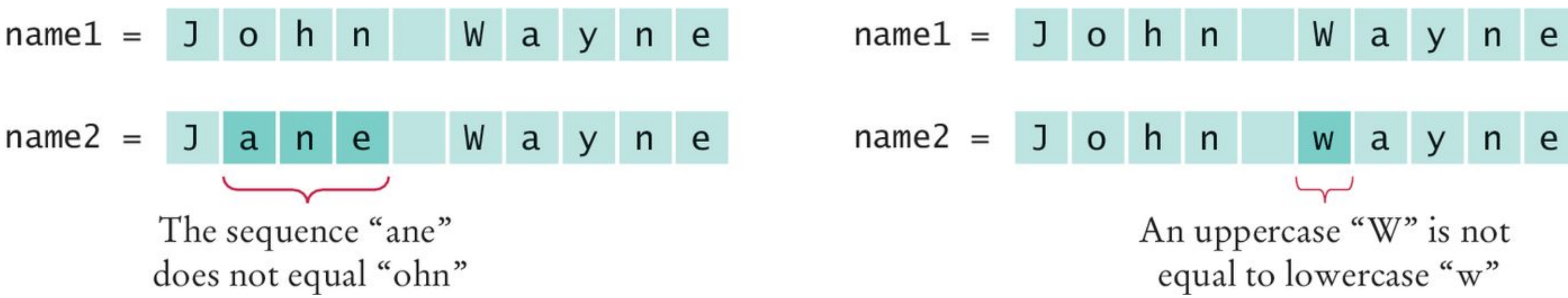
Checking for String Equality (1)

- For two strings to be equal, they must be of the same length and contain the same sequence of characters:



Checking for String Equality (2)

- If any character is different, the two strings will not be equal:



Relational Operator Examples (1)

Table 2 Relational Operator Examples		
Expression	**Value**	**Comment**
`3 <= 4`	True	3 is less than 4; <= tests for “less than or equal”.
`3 =< 4`	**Error**	The “less than or equal” operator is <=, not =<. The “less than” symbol comes first.
`3 > 4`	False	> is the opposite of <=.
`4 < 4`	False	The left-hand side must be strictly smaller than the right-hand side.
`4 <= 4`	True	Both sides are equal; <= tests for “less than or equal”.
`3 == 5 - 2`	True	== tests for equality.
`3 != 5 - 1`	True	!= tests for inequality. It is true that 3 is not 5 – 1.
`3 = 6 / 2`	**Error**	Use == to test for equality.
`1.0 / 3.0 == 0.333333333`	False	Although the values are very close to one another, they are not exactly equal. See Common Error 3.2 on page 101.
`"10" > 5`	**Error**	You cannot compare a string to a number.

Relational Operator Examples (2)

Table 2 Relational Operator Examples

🚫 `3 = 6 / 2`	**Error**	Use == to test for equality.
`1.0 / 3.0 == 0.333333333`	`False`	Although the values are very close to one another, they are not exactly equal. See Common Error 3.2 on page 101.
🚫 `"10" > 5`	**Error**	You cannot compare a string to a number.

Another Example

- Open the file:
  - compare.py
- Run the program
  - What are the results?

Common Error (Floating Point)

- Floating-point numbers have only a limited precision, and calculations can introduce roundoff errors.
- You must take these inevitable roundoffs into account when comparing floating point numbers.

Common Error (Floating Point, 2)

- For example, the following code multiplies the square root of 2 by itself.
- Ideally, we expect to get the answer 2:

```
r = math.sqrt(2.0)
if r * r == 2.0 :
   print("sqrt(2.0) squared is 2.0")
else :
   print("sqrt(2.0) squared is not 2.0 but", r * r)
```

```
Output:
sqrt(2.0) squared is not 2.0 but 2.0000000000000004
```

The Use of EPSILON

- Use a very small value to compare the difference to determine if floating-point values are '*close enough*'
  - The magnitude of their difference should be less than some threshold
  - Mathematically, we would write that x and y are close enough if:

$$|x - y| < \varepsilon$$

```
EPSILON = 1E-14
r = math.sqrt(2.0)
if abs(r * r - 2.0) < EPSILON :
   print("sqrt(2.0) squared is approximately 2.0")
```

Lexicographical Order

- To compare Strings in ‘dictionary’ like order:
  string1 < string2

- Notes
  - All UPPERCASE letters come before lowercase
  - ‘space’ comes before all other printable characters
  - Digits (0-9) come before all letters
  - See Appendix A for the Basic Latin (ASCII) Subset of Unicode

Operator Precedence

- The comparison operators have lower precedence than arithmetic operators
  - ***Calculations are done before the comparison***
  - Normally your calculations are on the 'right side' of the comparison or assignment operator

Calculations

```
actualFloor = floor + 1
```

```
if floor > height + 1 :
```

Implementing an `if` Statement (1)

1) Decide on a branching condition

   original price < 128?

2) Write pseudocode for the true branch

   discounted price = 0.92 x original price

3) Write pseudocode for the false branch

   discounted price = 0.84 x original price

Implementing an `if` Statement (2)

4) Double-check relational operators

- Test values below, at, and above the comparison (127, 128, 129)

5) Remove duplication

discounted price = ___ x original price

6) Test both branches

discounted price = 0.92 x 100 = 92

discounted price = 0.84 x 200 = 168

Implementing an `if` Statement (3)

7. Write the code in Python

A Third Example

- The university bookstore has a Kilobyte Day sale every October 24 (10.24), giving an 8 percent discount on all computer accessory purchases if the price is less than $128, and a 16 percent discount if the price is at least $128.

```
if originalPrice < 128 :
   discountRate = 0.92
else :
   discountRate = 0.84
discountedPrice = discountRate * originalPrice
```

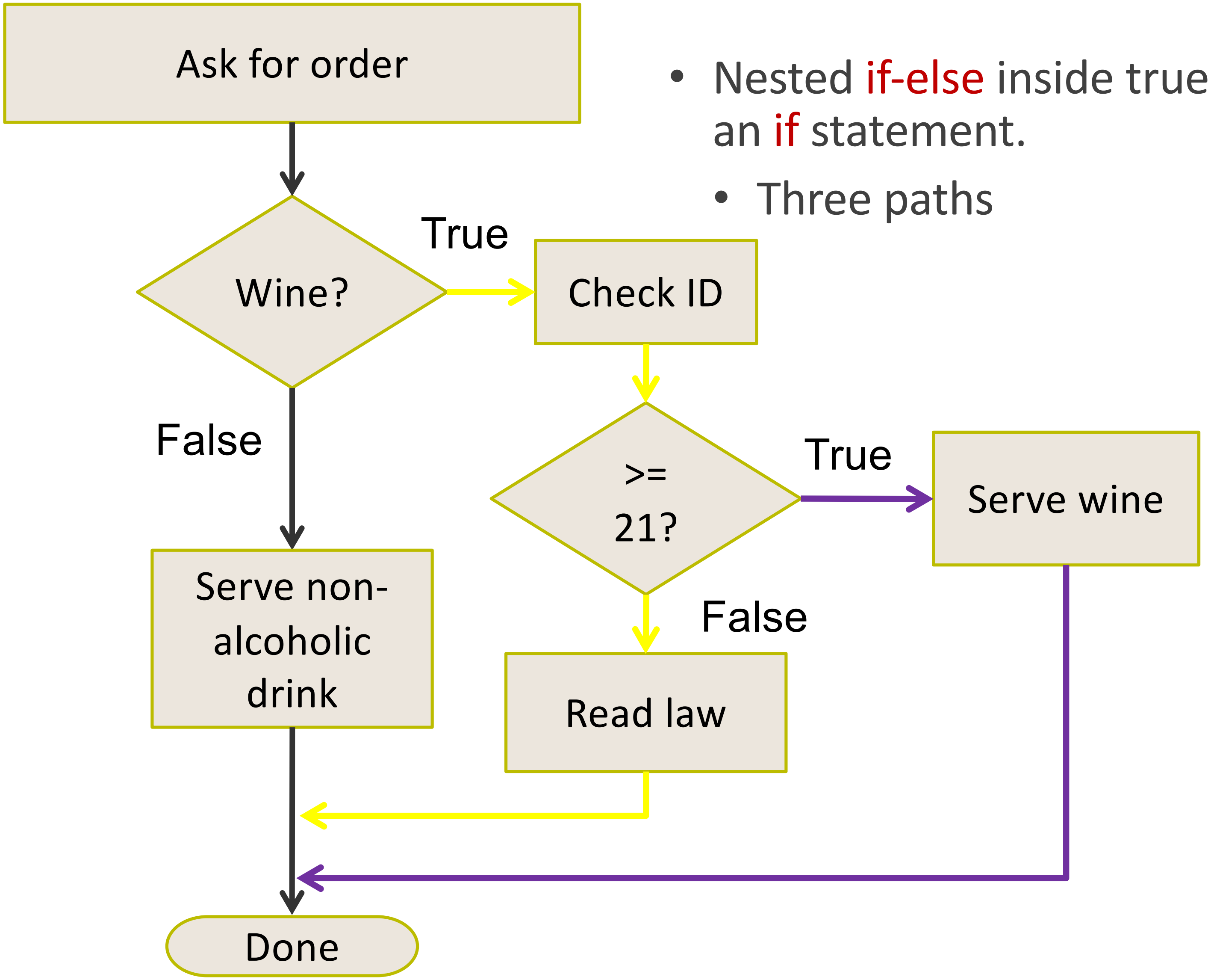
The Sale Example

- Open the file:
  - sale.py
- Run the program several time using different values
  - Use values less than 128
  - Use values greater that 128
  - Enter 128
- What results do you get?

Nested Branches

- You can *nest* an if inside either branch of an if statement.
- Simple example: Ordering drinks
  - Ask the customer for their drink order
  - `if` customer orders wine
    - Ask customer for ID
    - `if` customer's age is 21 or over
      - Serve wine
    - Else
      - Politely explain the law to the customer
  - Else
    - Serve customers a non-alcoholic drink

Flowchart of a Nested if



- Nested if-else inside true branch of an if statement.
  - Three paths

Tax Example: nested `if`s

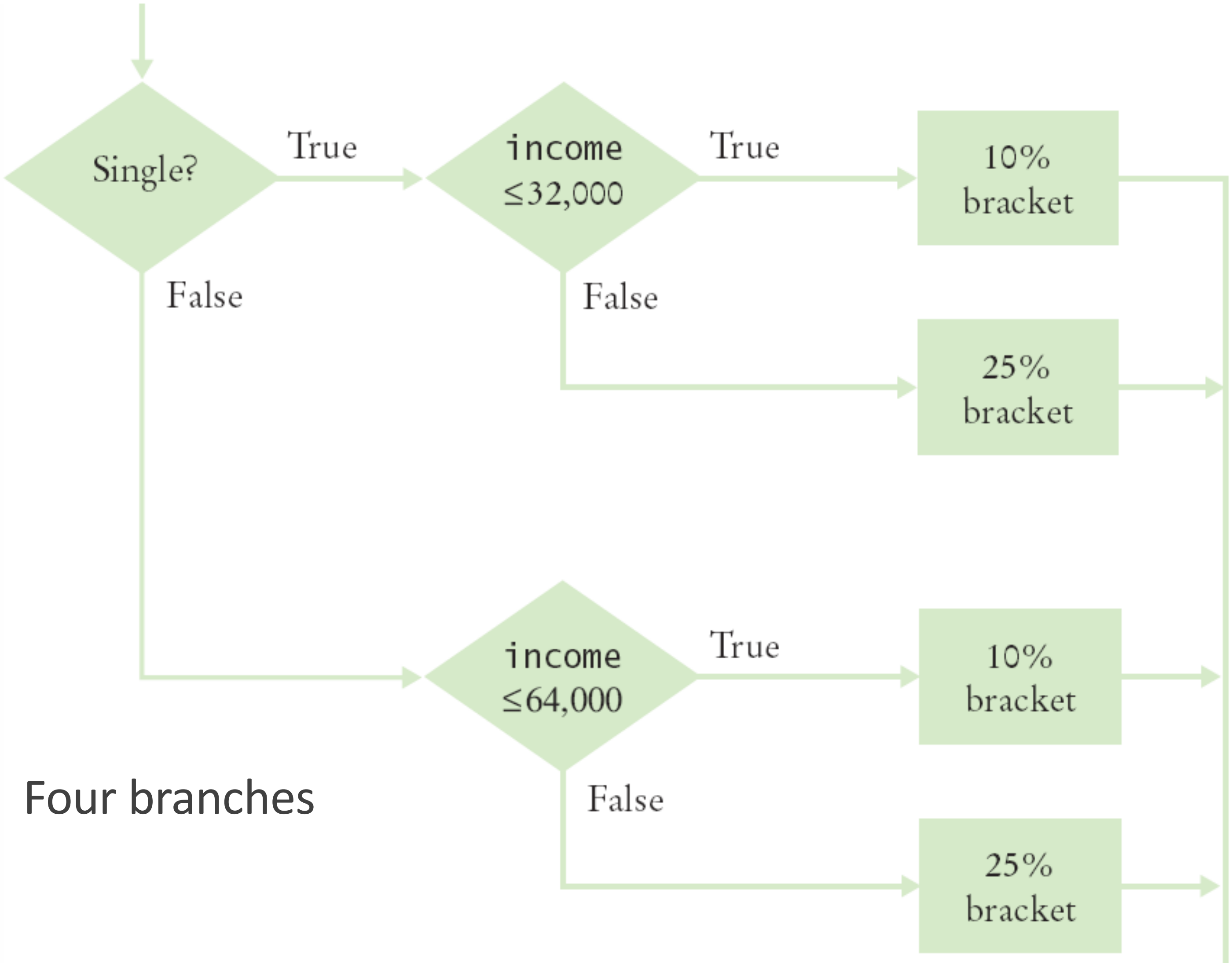
- Four outcomes (branches)

- Single
  - <= 32000
  - > 32000
- Married
  - <= 64000
  - > 64000

Table 3 Federal Tax Rate Schedule

If your status is Single and if the taxable income is	the tax is	of the amount over
at most \$32,000	10%	\$0
over \$32,000	\$3,200 + 25%	\$32,000
If your status is Married and if the taxable income is	**the tax is**	**of the amount over**
at most \$64,000	10%	\$0
over \$64,000	\$6,400 + 25%	\$64,000

Flowchart for the Tax Example



- Four branches

Taxes.py (1)

```
##
#   This program computes income taxes, using a simplified tax schedule.
#

# Initialize constant variables for the tax rates and rate limits.
RATE1 = 0.10
RATE2 = 0.25
RATE1_SINGLE_LIMIT = 32000.0
RATE1_MARRIED_LIMIT = 64000.0

# Read income and marital status.
income = float(input("Please enter your income: "))
maritalStatus = input("Please enter s for single, m for married: ")

# Compute taxes due.
tax1 = 0.0
tax2 = 0.0

if maritalStatus == "s" :
   if income <= RATE1_SINGLE_LIMIT :
      tax1 = RATE1 * income
   else :
      tax1 = RATE1 * RATE1_SINGLE_LIMIT
      tax2 = RATE2 * (income - RATE1_SINGLE_LIMIT)
else :
   if income <= RATE1_MARRIED_LIMIT :
      tax1 = RATE1 * income
   else :
      tax1 = RATE1 * RATE1_MARRIED_LIMIT
      tax2 = RATE2 * (income - RATE1_MARRIED_LIMIT)

totalTax = tax1 + tax2
```

Taxes.py (2)

- The ‘True’ branch (Single)
  - Two branches within this branch

```
if maritalStatus == "s" :
   if income <= RATE1_SINGLE_LIMIT :
      tax1 = RATE1 * income
   else :
      tax1 = RATE1 * RATE1_SINGLE_LIMIT
      tax2 = RATE2 * (income - RATE1_SINGLE_LIMIT)
```

Taxes.py (3)

- The 'False' branch (Married)

```
else :
    if income <= RATE1_MARRIED_LIMIT :
        tax1 = RATE1 * income
    else :
        tax1 = RATE1 * RATE1_MARRIED_LIMIT
        tax2 = RATE2 * (income - RATE1_MARRIED_LIMIT)
```

Running the Tax Example

- Open the file:
  - taxes.py
- Run the program several time using different values for income and marital status
  - Use income values less than $32,000
  - Use income values greater than $64,000
  - Enter "&" as the marital status
- What results do you get?

Hand-tracing

- Hand-tracing helps you understand whether a program works correctly
- Create a table of key variables
  - Use pencil and paper to track their values
- Works with pseudocode or code
  - Track location with a marker
- Use example input values that:
  - You know what the correct outcome should be
  - Will test each branch of your code

Hand-tracing the Tax Example

tax1	tax2	income	marital status
0	0		

- Setup
  - Table of variables
  - Initial values

```
RATE1 = 0.10
RATE2 = 0.25
RATE1_SINGLE_LIMIT = 32000.0
RATE1_MARRIED_LIMIT = 64000.0
```

```
# Compute taxes due.
tax1 = 0.0
tax2 = 0.0
```

Hand-tracing the Tax Example (2)

tax1	tax2	income	marital status
0	0	80000	m

- Input variables
  - From user
  - Update table

```
11 # Read income and marital status.
12 income = float(input("Please enter your income: "))
13 maritalStatus = input("Please enter s for single, m for married: ")
```

- Because marital status is not “s” we skip to the else on line 25

```
19 if maritalStatus == "s" :

25 else :
```

Hand-tracing the Tax Example (3)

- Because income is not <= 64000, we move to the else clause on line 28
  - Update variables on lines 29 and 30
  - Use constants

```
26     if income <= RATE1_MARRIED_LIMIT :
27        tax1 = RATE1 * income
28     else :
29        tax1 = RATE1 * RATE1_MARRIED_LIMIT
30        tax2 = RATE2 * (income - RATE1_MARRIED_LIMIT)
```

tax1	tax2	income	marital status
~~0~~	~~0~~	80000	m
6400	4000		

Incremental Code and Test

- Using the flag problem statement as an example:
  - Compute the data for the first panel
  - Print out the data
    - Color
    - The X and Y coordinates of the top left corner of the panel
    - The width of the panel
    - The height of the panel
  - Check the data
    - If the data is correct:
      - Draw the panel
    - Else
      - Look at your equations
      - Find and fix any errors
      - Check the data again
  - Do the next panel

Multiple Alternatives

3.4 Multiple Alternatives

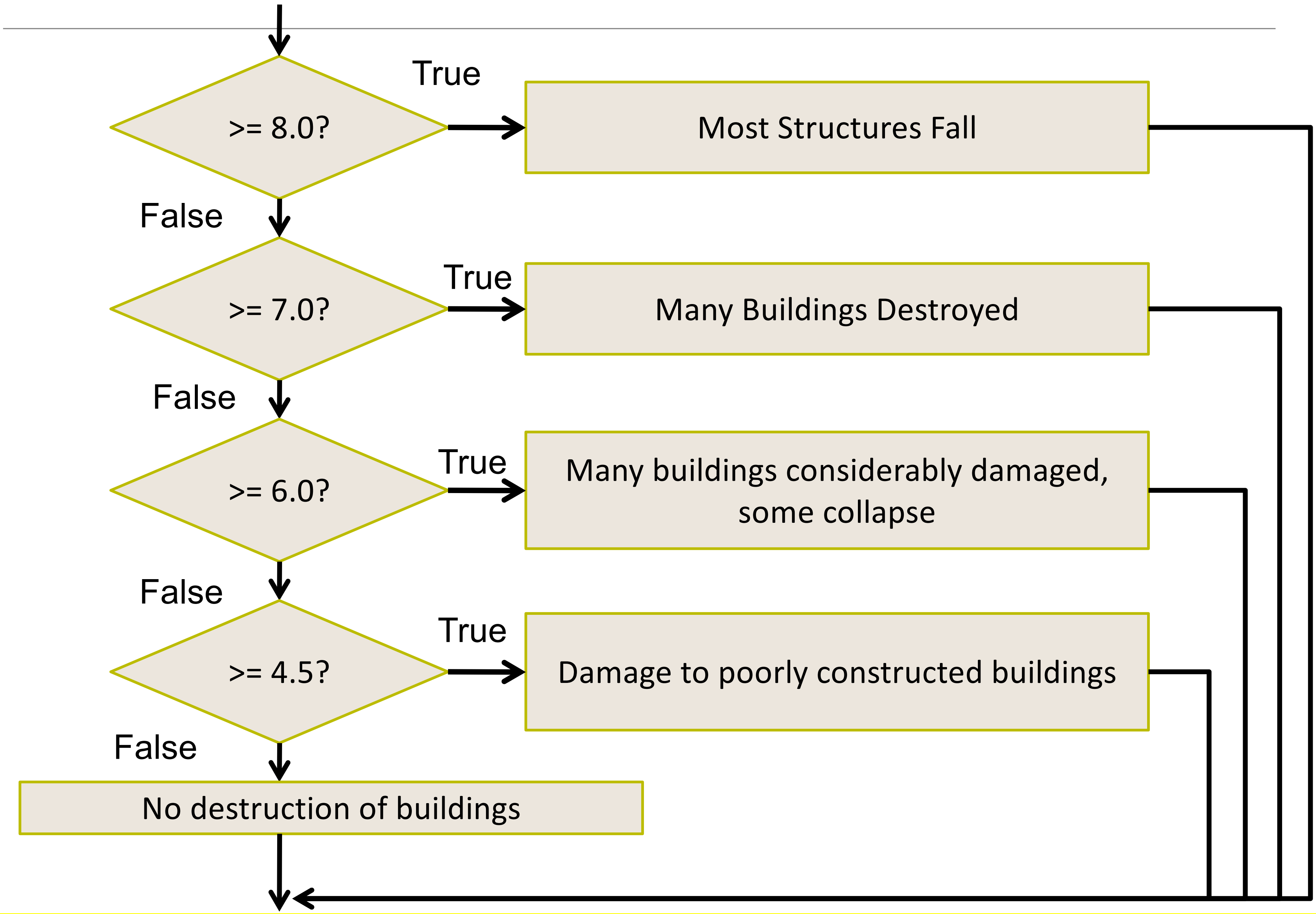
- What if you have more than two branches?
- Count the branches for the following earthquake effect example:
  - 8 (or greater)
  - 7 to 7.99
  - 6 to 6.99
  - 4.5 to 5.99
  - Less than 4.5

When using multiple `if` statements, test the general conditions after the more specific conditions.

Table 4 Richter Scale

Value	Effect
8	Most structures fall
7	Many buildings destroyed
6	Many buildings considerably damaged, some collapse
4.5	Damage to poorly constructed buildings

Flowchart of Multiway Branching



`elif` Statement

- Short for Else, if…
- As soon as one on the test conditions succeeds, the statement block is executed
  - No other tests are attempted
- If none of the test conditions succeed the final else clause is executed

if, elif Multiway Branching

```
if richter >= 8.0 :    # Handle the ‘special case’ first
   print("Most structures fall")
elif richter >= 7.0 :
   print("Many buildings destroyed")
elif richter >= 6.0 :
   print("Many buildings damaged, some collapse")
elif richter >= 4.5 :
   print("Damage to poorly constructed buildings")
else :     # so that the ‘general case’ can be handled last
   print("No destruction of buildings")
```

What is Wrong With This Code?

```
if richter >= 8.0 :
   print("Most structures fall")
if richter >= 7.0 :
   print("Many buildings destroyed")
if richter >= 6.0 :
   print("Many buildings damaged, some collapse")
if richter >= 4.5 :
   print("Damage to poorly constructed buildings")
```

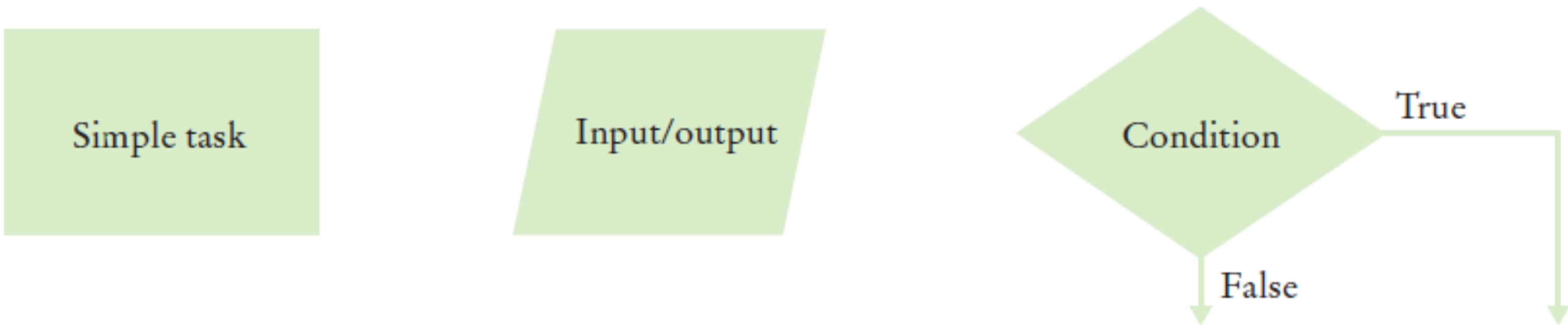
earthquake Example

- Open the file:
  - earthquake.py
- Run the program with several different inputs

Using Flowcharts to Develop and Refine Algorithms

3.5 Problem Solving: Flowcharts

- You have seen a few basic flowcharts
- A flowchart shows the structure of decisions and tasks to solve a problem
- Basic flowchart elements:



- Connect them with arrows
  - But never point an arrow inside another branch!

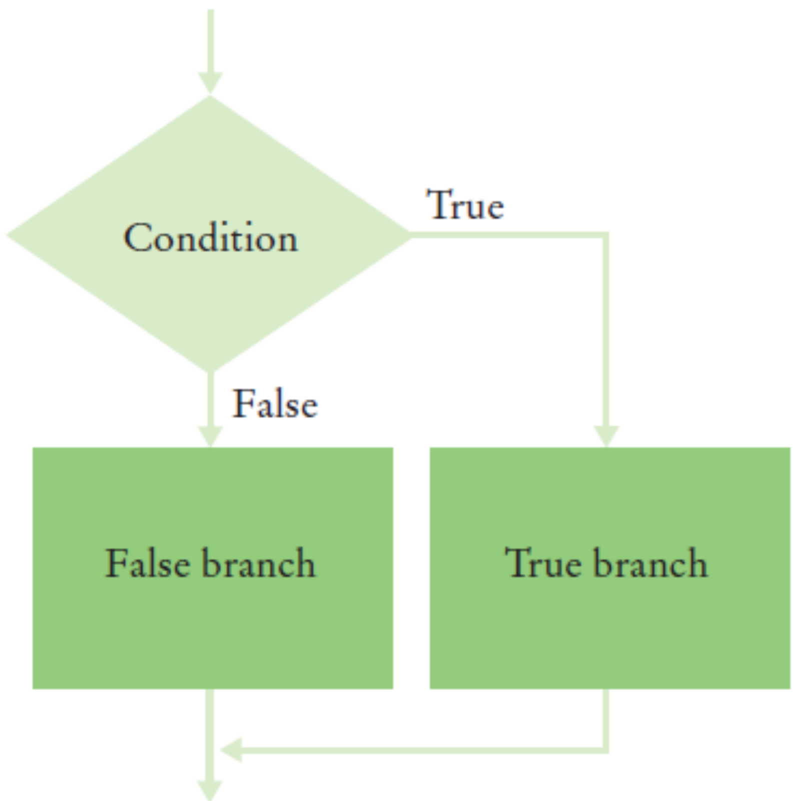
Each branch of a decision can contain tasks and further decisions

Using Flowcharts

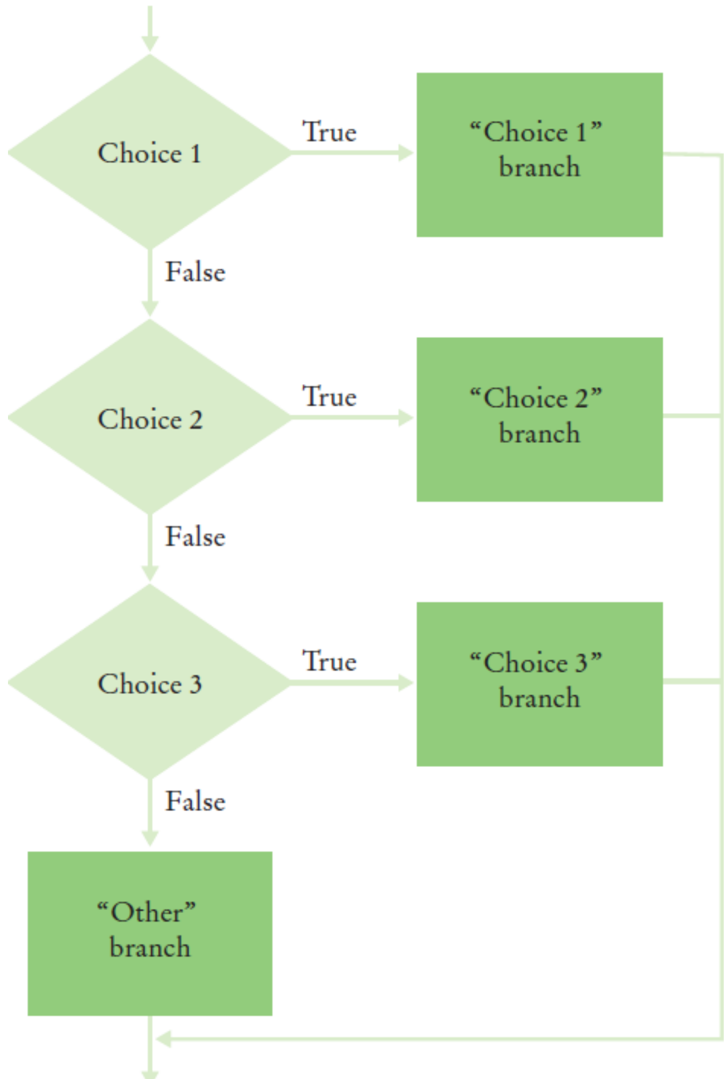
- Flowcharts are an excellent tool
- They can help you visualize the flow of your algorithm
- Building the flowchart
  - Link your tasks and input / output boxes in the sequence they need to be executed
  - When you need to make a decision use the diamond (a conditional statement) with two outcomes
  - Never point an arrow inside another branch

Conditional Flowcharts

Two Outcomes



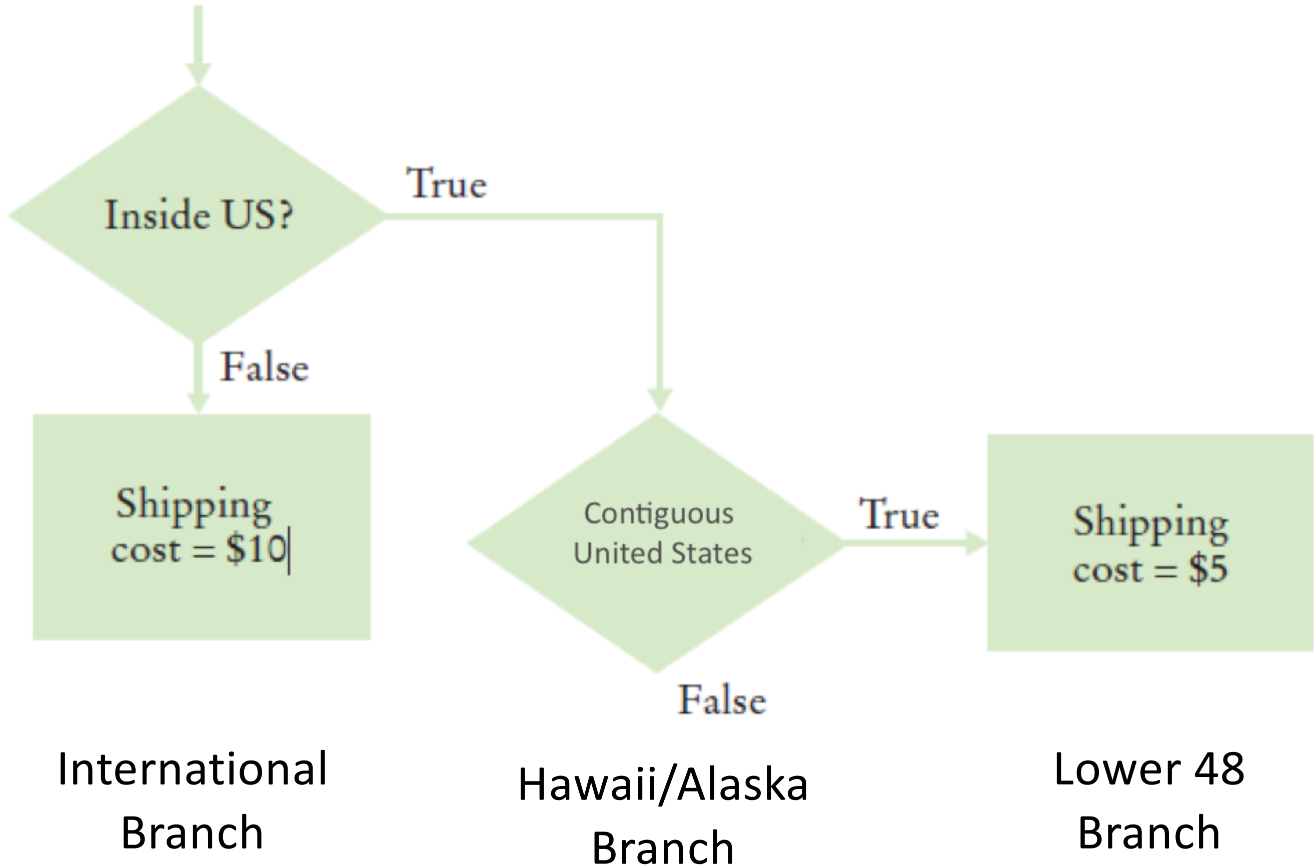
Multiple Outcomes



Shipping Cost flowchart

Shipping costs are $5 inside the contiguous the United States (Lower 48 states), and $10 to Hawaii and Alaska. International shipping costs are also $10.

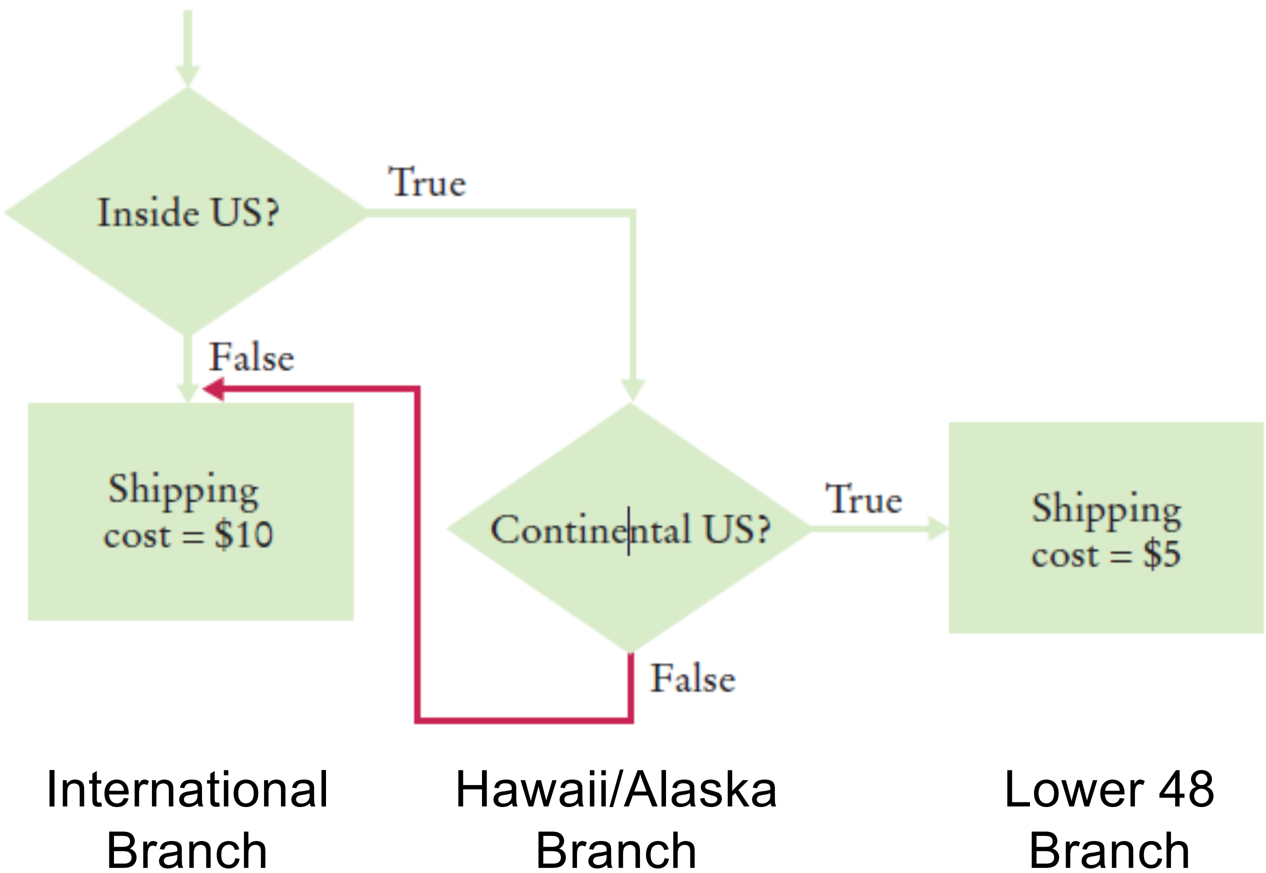
- Three Branches:



Don’t Connect Branches!

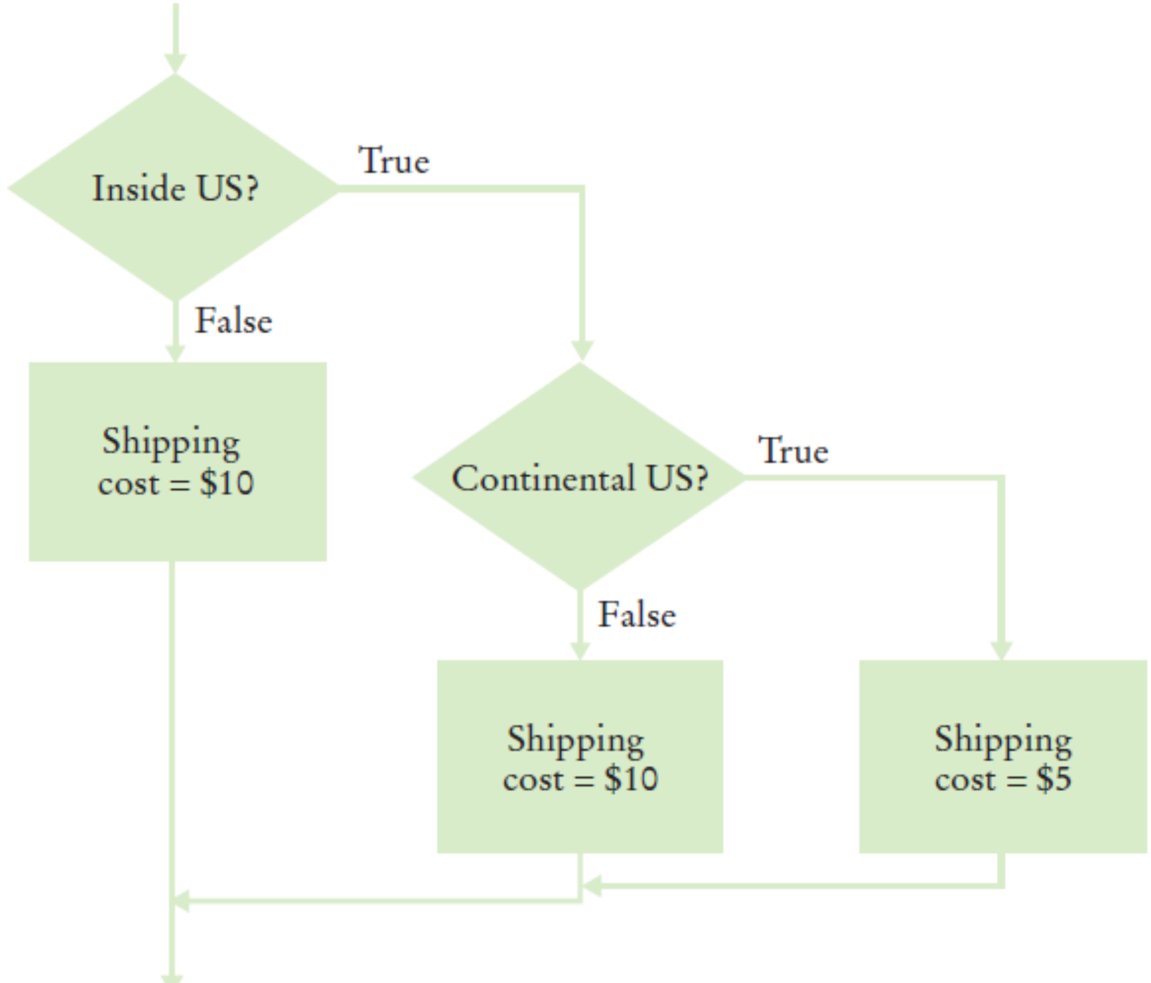
Shipping costs are $5 inside the United States, except that to Hawaii and Alaska they are $10. International shipping costs are also $10.

- Don’t do this!



Shipping Cost Flowchart

Shipping costs are $5 inside the United States, except that to Hawaii and Alaska they are $10. International shipping costs are also $10.



Shipping Example

- Open the file:
  - Shipping.py
- Run the program with several different inputs?
  - What happens if you enter “usa” as the country?
- We will learn several ways to correct the code later in this chapter

Complex Decision Making is Hard

- Computer systems are used to help sort and route luggage at airports
- The systems:
  - Scan the baggage tags
  - Sorts the items
  - Routes the items to conveyor belts
  - Humans then place the bags on trucks
- In 1993 Denver built a new airport with a "state of the art" luggage system that replaced the human operators with robotic carts
  - The system failed
  - The airport could not open with out a luggage system
  - The system was replaced (it took over a year)
  - The cost was almost $1B…. (yes one billion… 1994 dollars)
  - The company that designed the system went bankrupt

Building Test Cases

Problem Solving: Test Cases

- Aim for complete coverage of all decision points:
  - There are two possibilities for the marital status and two tax brackets for each status, yielding four test cases
  - Test a handful of boundary conditions, such as an income that is at the boundary between two tax brackets, and a zero income
  - If you are responsible for error checking (which is discussed in Section 3.9), also test an invalid input, such as a negative income
- Each branch of your code should be covered with a test case

Choosing Test Cases

- Choose input values that:
  - Test boundary cases and 0 values
  - Test each branch

Test Case	Expected Output	Comment
30,000 s	3,000	10% bracket
72,000 s	13,200	3,200 + 25% of 40,000
50,000 m	5,000	10% bracket
104,000 m	16,400	6,400 + 25% of 40,000
32,000 s	3,200	boundary case
0 s	0	boundary case

Make a Schedule…

- Make a reasonable estimate of the time it will take you to:
  - Design the algorithm
  - Develop test cases
  - Translate the algorithm to code and enter the code
  - Test and debug your program
- Leave some extra time for unanticipated problems

As you gain more experience your estimates will become more accurate. It is better to have some extra time than to be late

Boolean Variables and Operators

Boolean Variables

- Boolean Variables
  - A Boolean variable is often called a flag because it can be either up (`true`) or down (`false`)
  - boolean is a Python data type
    - `failed = True`
  - Boolean variables can be either `True` or `False`
- There are two Boolean Operators: `and, or`
  - They are used to combine multiple conditions

Combined Conditions: and

- Combining two conditions is often used in range checking
  - Is a value between two other values?
- Both sides of the *and* must be true for the result to be true

```
if temp > 0 and temp < 100 :
   print("Liquid")
```

A	B	A and B
True	True	True
True	False	False
False	True	False
False	False	False

Combined Conditions: or

- We use or if only one of two conditions need to be true
  - Use a compound conditional with an or:

```
if temp <= 0 or temp >= 100
   :
   print("Not liquid")
```

- If either condition is true
  - The result is true

A	B	A or B
True	True	True
True	False	True
False	True	True
False	False	False

The *not* operator: not

- If you need to invert a boolean variable or comparison, precede it with not

```
if not attending or grade < 60 :
   print("Drop?")
```

```
if attending and not(grade < 60) :
   print("Stay")
```

A	not A
True	False
False	True

- If you are using not, try to use simpler logic:

```
if attending and grade >= 60 :
   print("Stay")
```

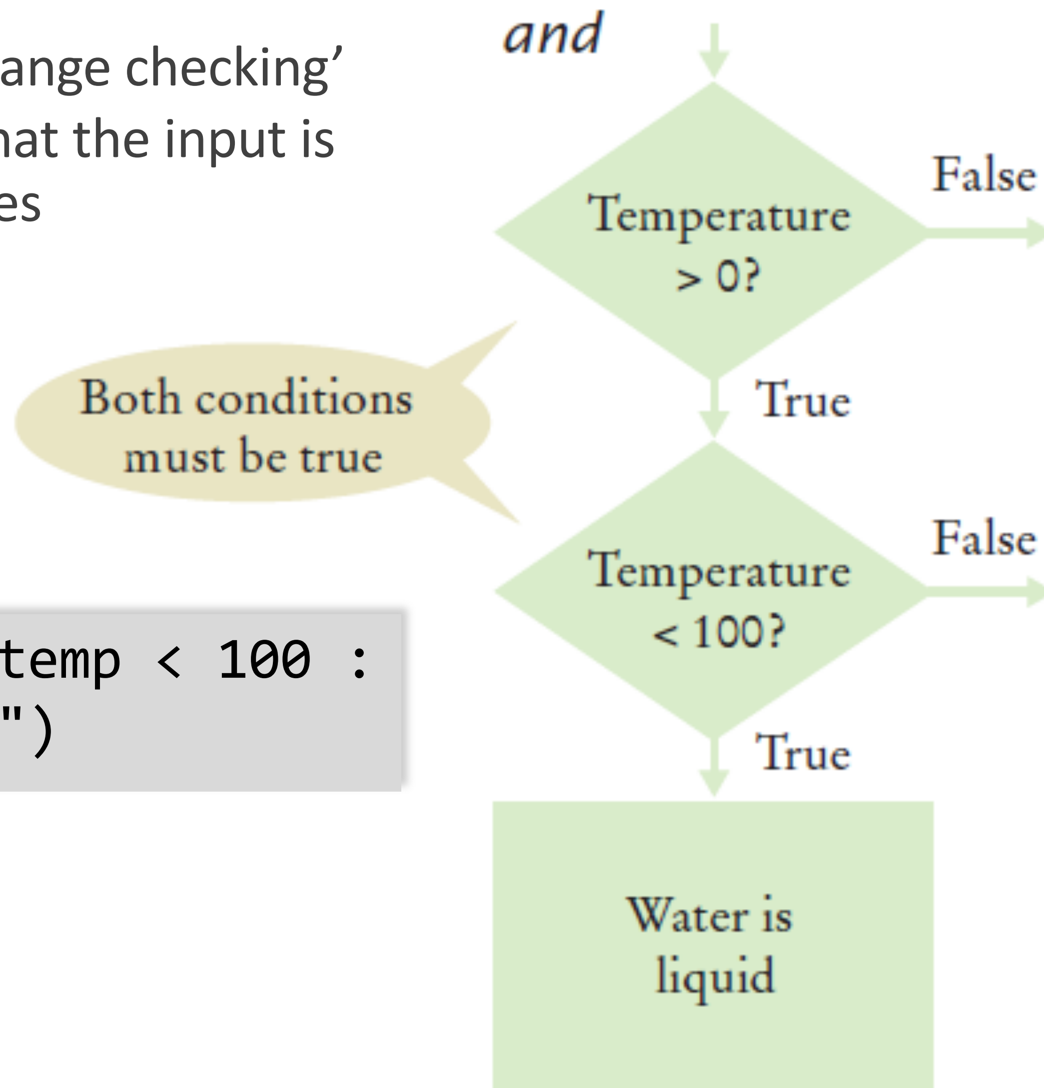
The *not* operator: inequality !

- A slightly different operator is used for the `not` when checking for inequality rather than negation.
- Example inequality:
  - The password that the user entered is not equal to the password on file.
  - `if userPassword != filePassword :`

and Flowchart

- This is often called ‘range checking’
  - Used to validate that the input is between two values

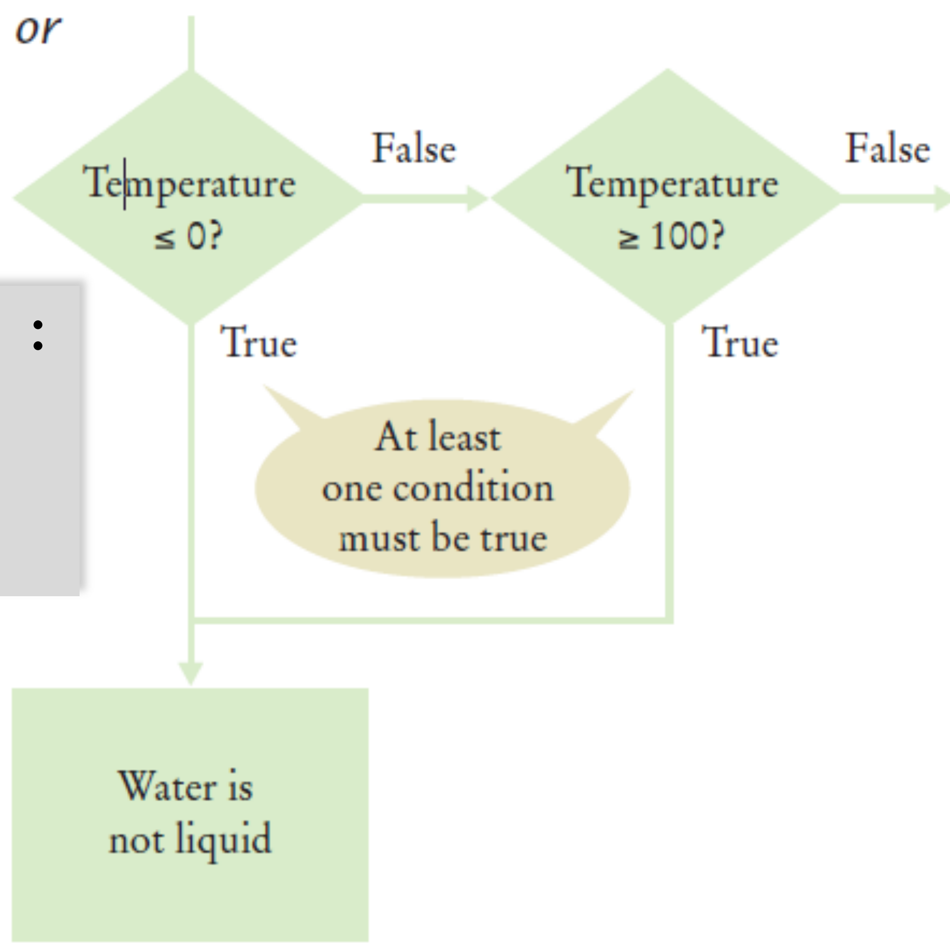
```
if temp > 0 and temp < 100 :
   print("Liquid")
```



or flowchart

- Another form of ‘range checking’
  - Checks if value is outside a range

```
if temp <= 0 or temp >= 100 :
   print("Not Liquid")
```



Comparison Example

- Open the file:
  - Compare2.py
- Run the program with several inputs

Boolean Operator Examples

Table 5 Boolean Operator Examples

Expression	Value	Comment
`0 < 200 and 200 < 100`	`False`	Only the first condition is true.
`0 < 200 or 200 < 100`	`True`	The first condition is true.
`0 < 200 or 100 < 200`	`True`	The `or` is not a test for "either-or". If both conditions are true, the result is true.
`0 < x and x < 100 or x == -1`	`(0 < x and x < 100) or x == -1`	The `and` operator has a higher precedence than the `or` operator (see Appendix B).
`not (0 < 200)`	`False`	`0 < 200` is `true`, therefore its negation is `false`.
`frozen == True`	`frozen`	There is no need to compare a Boolean variable with `True`.
`frozen == False`	`not frozen`	It is clearer to use `not` than to compare with `False`.

Common Errors with Boolean Conditions

Confusing and and or Conditions

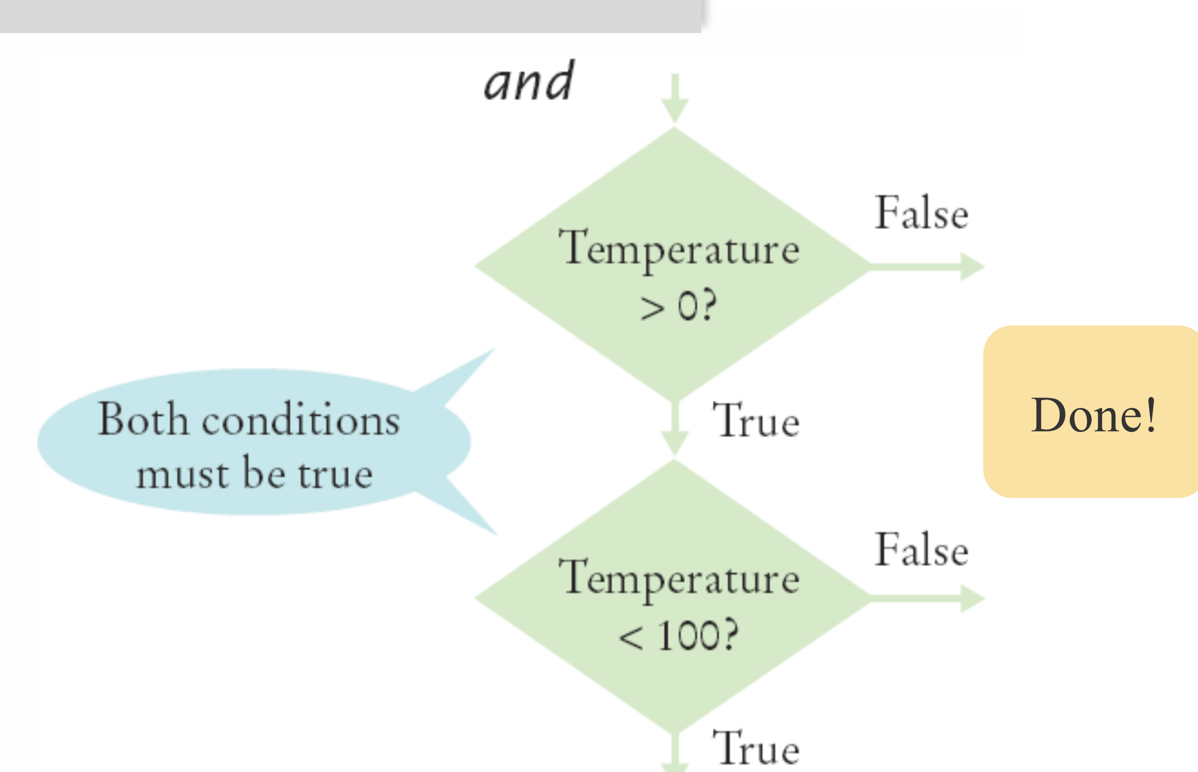
- It is a surprisingly common error to confuse and and or conditions.
- A value lies between 0 and 100 if it is at least 0 ***and*** at most 100.
- It lies outside that range if it is less than 0 ***or*** greater than 100.

- There is no golden rule; you just have to think carefully.

Short-circuit Evaluation: and

- Combined conditions are evaluated from left to right
  - If the left half of an *and* condition is false, why look further?

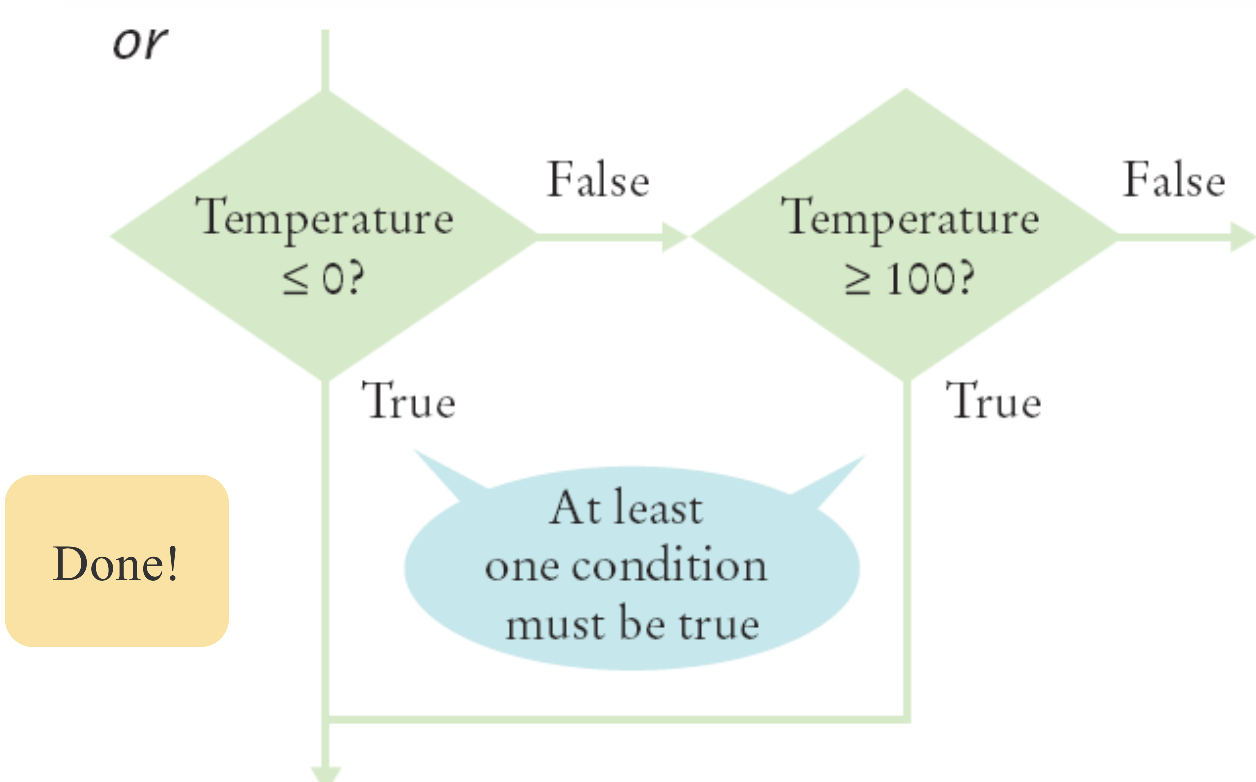
```
if temp > 0 and temp < 100 :
   print("Liquid")
```



Short-circuit evaluation: or

- If the left half of the *or* is true, why look further?

```
if temp <= 0 or temp >= 100 :
   print("Not Liquid")
```



De Morgan's law

- De Morgan's law tells you how to negate and and or conditions:
  - not(A and B) is the same as notA or notB
  - not(A or B) is the same as notA and notB
- Example: Shipping is higher to AK and HI

```
if (country != "USA"
   and state != "AK"
   and state != "HI") :
   shippingCharge = 20.00
```

```
if not(country=="USA"
  or state=="AK"
  or state=="HI") :
   shippingCharge = 20.00
```

- To simplify conditions with negations of *and* or *or* expressions, it's a good idea to apply De Morgan's law to move the negations to the innermost level.

Analyzing Strings

Analyzing Strings – The in Operator

- Sometimes it's necessary to analyze or ask certain questions about a particular string.
  - Sometimes it is necessary to determine if a string contains a given substring. That is, one string contains an exact match of another string.
  - Given this code segment,

    ```
    name = "John Wayne"
    ```

  - the expression

    ```
    "Way" in name
    ```

  - yields `True` because the substring `"Way"` occurs within the string stored in variable name.
  - The **`not in`** operator is the inverse on the in operator

Substring: Suffixes

- Suppose you are given the name of a file and need to ensure that it has the correct extension

```
if filename.endswith(".html") :
   print("This is an HTML file.")
```

- The `endswith()` string method is applied to the string stored in filename and returns `True` if the string ends with the substring ".html" and `False` otherwise.

Operations for Testing Substrings

Table 6 Operations for Testing Substrings

Operation	Description
substring `in` *s*	Returns `True` if the string *s* contains *substring* and `False` otherwise.
s`.count(`*substring*`)`	Returns the number of non-overlapping occurrences of *substring* in the string *s*.
s`.endswith(`*substring*`)`	Returns `True` if the string *s* ends with the `substring` and `False` otherwise.
s`.find(`*substring*`)`	Returns the lowest index in the string *s* where *substring* begins, or –1 if *substring* is not found.
s`.startswith(`*substring*`)`	Returns `True` if the string *s* begins with *substring* and `False` otherwise.

Methods: Testing String Characteristics (1)

Table 7 Methods for Testing String Characteristics

Method	Description
`s.isalnum()`	Returns `True` if string *s* consists of only letters or digits and it contains at least one character. Otherwise it returns `False`.
`s.isalpha()`	Returns `True` if string *s* consists of only letters and contains at least one character. Otherwise it returns `False`.
`s.isdigit()`	Returns `True` if string *s* consists of only digits and contains at least one character. Otherwise, it returns `False`.

Methods for Testing String Characteristics (2)

Table 7 Methods for Testing String Characteristics

`s.islower()`	Returns `True` if string *s* contains at least one letter and all letters in the string are lowercase. Otherwise, it returns `False`.
`s.isspace()`	Returns `True` if string *s* consists of only white space characters (blank, newline, tab) and it contains at least one character. Otherwise, it returns `False`.
`s.isupper()`	Returns `True` if string *s* contains at least one letter and all letters in the string are uppercase. Otherwise, it returns `False`.

Comparing and Analyzing Strings (1)

Table 8 Comparing and Analyzing Strings

Expression	Value	Comment
`"John" == "John"`	`True`	`==` is also used to test the equality of two strings.
`"John" == "john"`	`False`	For two strings to be equal, they must be identical. An uppercase "J" does not equal a lowercase "j".
`"john" < "John"`	`False`	Based on lexicographical ordering of strings an uppercase "J" comes before a lowercase "j" so the string `"john"` follows the string `"John"`. See Special Topic 3.2 on page 101.
`"john" in "John Johnson"`	`False`	The substring `"john"` must match exactly.
`name = "John Johnson"` `"ho" not in name`	`True`	The string does not contain the substring `"ho"`.
`name.count("oh")`	`2`	All non-overlapping substrings are included in the count.
`name.find("oh")`	`1`	Finds the position or string index where the first substring occurs.
`name.find("ho")`	`-1`	The string does not contain the substring `ho`.
`name.startswith("john")`	`False`	The string starts with `"John"` but an uppercase "J" does not match a lowercase "j".
`name.isspace()`	`False`	The string contains non-white space characters.
`name.isalnum()`	`False`	The string also contains blank spaces.
`"1729".isdigit()`	`True`	The string only contains characters that are digits.
`"-1729".isdigit()`	`False`	A negative sign is not a digit.

Comparing and Analyzing Strings (2)

Table 8 Comparing and Analyzing Strings

`name.startswith("john")`	`False`	The string starts with `"John"` but an uppercase “J” does not match a lowercase “j”.
`name.isspace()`	`False`	The string contains non-white space characters.
`name.isalnum()`	`False`	The string also contains blank spaces.
`"1729".isdigit()`	`True`	The string only contains characters that are digits.
`"-1729".isdigit()`	`False`	A negative sign is not a digit.

Substring Example

- Open the file:
  - Substrings.ph
- Run the program and test several strings and substrings

Input Validation

Input Validation

- Accepting user input is dangerous
  - Consider the Elevator program:
  - Assume that the elevator panel has buttons labeled 1 through 20 (but not 13).

Input Validation

- The following are illegal inputs:
  - The number 13

```
if floor == 13 :
    print("Error: There is no thirteenth floor.")
```

  - Zero or a negative number
  - A number larger than 20

```
if floor <= 0 or floor > 20 :
    print("Error: The floor must be between 1 and 20.")
```

  - An input that is not a sequence of digits, such as five:
    - Python's exception mechanism is needed to help verify integer and floating point values (Chapter 7).

Elevatorsim2.py

```
##
#  This program simulates an elevator panel that skips the 13th floor,
#   checking for input errors.
#

# Obtain the floor number from the user as an integer.
floor = int(input("Floor: "))

# Make sure the user input is valid.
if floor == 13 :
   print("Error: There is no thirteenth floor.")
elif floor <= 0 or floor > 20 :
   print("Error: The floor must be between 1 and 20.")
else :
   # Now we know that the input is valid.
   actualFloor = floor
```

Elevator Simulation

- Open the file:
  - elevatorsim2.py
- Test the program with a range of inputs including:
  - 12
  - 14
  - 13
  - -1
  - 0
  - 23
  - 19

Chapter Three Review

Summary: `if` Statement

- The if statement allows a program to carry out different actions depending on the nature of the data to be processed.
- Relational operators (`<  <=  >  >=  ==  !=`) are used to compare numbers and `String`s.
- `String`s are compared in lexicographic order.
- Multiple `if` statements can be combined to evaluate complex decisions.
- When using multiple `if` statements, test general conditions after more specific conditions.

Summary: Flowcharts and Testing

- When a decision statement is contained inside the branch of another decision statement, the statements are *nested.*
- Nested decisions are required for problems that have two levels of decision making.
- Flow charts are made up of elements for tasks, input/output, and decisions.
- Each branch of a decision can contain tasks and further decisions.
- Never point an arrow inside another branch.
- Each branch of your program should be covered by a test case.
- It is a good idea to design test cases before implementing a program.

Summary: Boolean

- The type `boolean` has two values, **true** and **false**.
  - Python has two Boolean operators that combine conditions: **and** and **or**.
  - To invert a condition, use the *`not`* operator.
  - When checking for equality use the `!` operator.
  - The **and** and **or** operators are computed lazily:
    - As soon as the truth value is determined, no further conditions are evaluated.
  - De Morgan's law tells you how to negate **and** and **or** conditions.