CMSC201
Computer Science I for Majors

Lecture 04 – Decision Structures

Last Class We Covered

- Python's operators
  - Arithmetic operators
    - Mod and integer division
  - Assignment operators
  - Comparison operators
  - Boolean operators

- The order of operations

Any Questions from Last Time?

Today's Objectives

- To get practice using the Boolean data type
- To understand how to use decision structures
  - One-way (using **`if`**)
  - Two-way (using **`if`** and **`else`**)
  - Multi-way (using **`if`**, **`elif`**, and **`else`**)
- To learn about nested decision structures

Quick Note about `main()`

`main()`

- In Lab 2, we introduced the code

```
def main():
```

  as the first line of code in our file

- **`main()`** is an example of a **function**
- We can use functions to organize our code
  - We'll cover them in detail later this semester

Functions

- For now, think of functions as something similar to a variable
  - Variables hold data
  - Functions hold code

- We use the variable's name to access its data
- We use the function's name to access its code

Using `main()` for Your Code

- From now on, use `main()` in your code
  - Every file in your HW1 should have `main()`

declaring our `main()` function

```
def main():
    className = input("What class is this? ")
    print(className, "is awesome!")

main()
```

calling our `main()` function

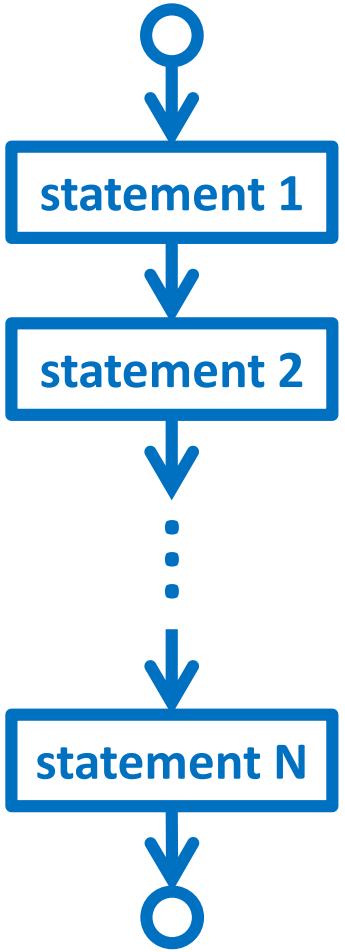
Control Structures

Control Structures

- Structures that control how the program "flows" or operates, and in what order
- Sequence  we've already seen this
- Decision Making what we're covering today
- Looping

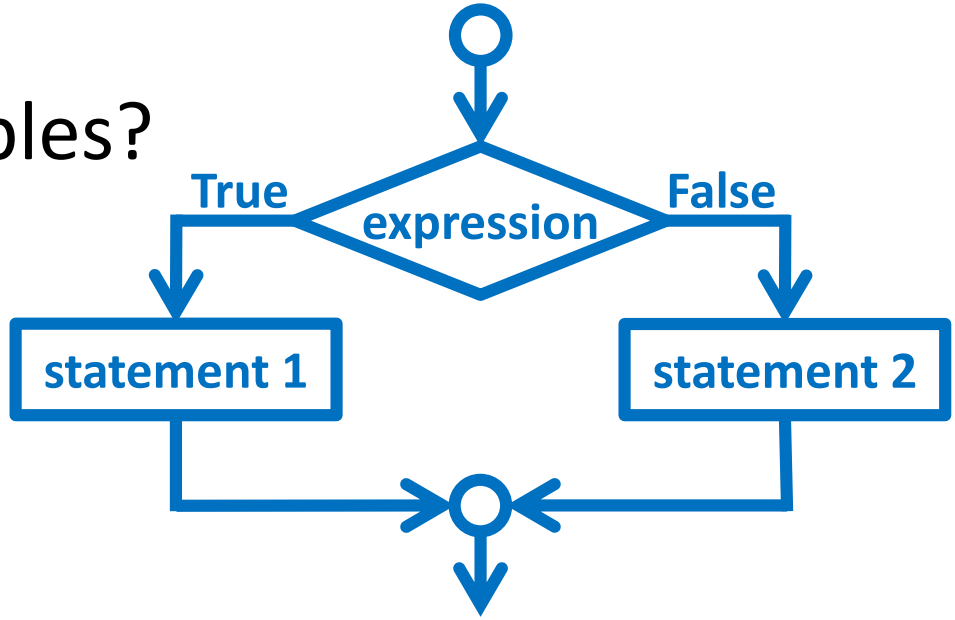
Sequence

- One step after another, with no choices to make
- Homework 1 will be full of these
- What are some real life examples?
  - Dialing a phone number
  - Purchasing and paying for groceries



Decision Making

- Selecting one choice from many based on a specific reason or condition
  - If something is true, do **A** … if it's not, do **B**
- Some real life examples?
  - What homework to work on tonight
  - Choosing where to eat lunch



Decision Making

- Why did we spend so much time on comparison operators and logical operators last time?

- Because we can use them to *control* how our program works and what code it runs
  - By using the decision structures

One-Way Decision Structures

One-Way Decision Structures

- Decision structures let Python make choices
  - Based on some condition

```
def main():
    weight = float(input("How heavy is your bag? "))
    if weight > 50:
        print("That bag is too heavy.")
        print("There will be a $25 charge.")

    print("Thank you for your business.")

main()
```

"`if`" Statements

- The Python `if` statement is used to implement the decision

```
if <condition>:
    <body>
```

- The **condition** must evaluate to `True` or `False`
- The **body** is a sequence of one or more statements indented under the `if` heading

Formatting Decision Structures

- Each `if` statement must close with a colon
  - Two vertical dots (`:`)

- Code in the **`body`** (that is executed as part of the `if` statement) must be indented
  - By four spaces
  - Hitting the "Tab" key in many editors (including emacs) will automatically indent it by four spaces

"`if`" Semantics

- The semantics of the **`if`** should be clear
  - First, the condition in the heading is evaluated
  - If the condition is **`True`**
    - The statements in the body are executed
    - Control passes to the next statement in the program
  - If the condition is **`False`**
    - The statements in the body are skipped
    - Control passes to the next statement in the program

One-Way Decisions

- The body of the **`if`** either executes or not depending on the condition
- Control then passes to the next (non-body) statement after the **`if`**

- This is a ***one-way*** or ***simple*** decision

One-Way Example: Temperature

- You're studying abroad, and need to convert the temperature from Celsius to Fahrenheit

```
def main():
    celsius = float(input("What is temp in Celsius? "))
    fahrenheit = 9/5 * celsius + 32

    print("The temperature is", fahrenheit, \
                "degrees Fahrenheit.")

main()
```

Temperature Warnings

- Let's now modify the program to print a warning when the weather is extreme

- Any temperature that is…
  - Over 95 degrees Fahrenheit
    - Will cause a hot weather warning
  - Lower than 32 degrees Fahrenheit
    - Will cause a cold weather warning

Temperature Example Code

```
def main():
    celsius = float(input("What is temp in Celsius? "))
    fahrenheit = 9 / 5 * celsius + 32
    print("The temperature is", fahrenheit, \
          "degrees Fahrenheit.")
    if fahrenheit > 95:
        print("It's really hot out there, be careful!")
    if fahrenheit < 32:
        print("Brrrrr. Be sure to dress warmly!")


main()
```

Temperature Example Code

```
def main():
    celsius = float(input("What is temp in Celsius? "))
    fahrenheit = 9 / 5 * celsius + 32
    print("The temperature is", fahrenheit, \
          "degrees Fahrenheit.")
    if fahrenheit > 95:
        print("It's really hot out there, be careful!")
    if fahrenheit < 32:
        print("Brrrrr. Be sure to dress warmly!")
```

```
main()
```

this is the main level of our program

this level of the code is only executed if `fahrenheit > 95`

this level of the code is only executed if `fahrenheit < 32`

Two-Way Decision Structures

Two-Way Decisions

- In Python, a ***two-way decision*** can be used by adding an **`else`** clause onto an **`if`** clause

- This is called an **if-else** decision structure:

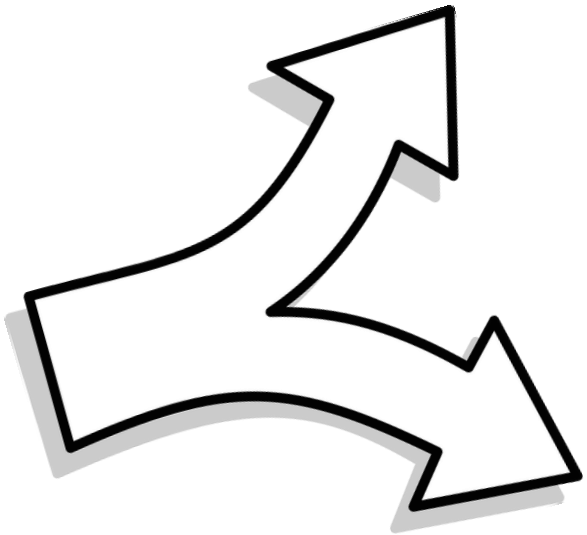
```
if <condition>:
    <codeA statements>
else:
    <codeB statements>
```

How Python Handles `if-else`

- Python will evaluate the condition, and then…
  - If the condition is **`True`**, the set of **`codeA`** statements under the **`if`** are executed
  - If the condition is **`False`**, the set of **`codeB`** statements under the **`else`** are executed
- The code that comes after the **`if-else`** is executed only after one of the sets of statements is executed

Two-Way Code Framework

```
if theCondition:
    <codeA statements>
else:
    <codeB statements>
```



- Only execute **codeA** if **theCondition** is True
- If **theCondition** is not True, run **codeB**

Simple Two-Way Example

```
def main():
    x = int(input("What is the value of X? "))
    if x > 5:
        print("X is larger than five!")
    else:
        print("X is less than or equal to five!")

main()
```

only one of these will execute

this is the main level of our program

this statement is only executed if `x > 5` is `True`

this statement is only executed if `x > 5` is `False`

Simple Two-Way Example #2

```
def main():
    num = int(input("Enter a number: "))

    if num % 2 == 0:
        print("Your number is even.")
    else:
        print("Your number is odd.")

    print(num, "is a good number!")
main()
```

when is this line executed?

Multi-Way Decision Structures

Bigger (and Better) Decision Structures

- One-way and two-way structures are limited

- What if we have multiple exclusive outcomes?
  - ***Exclusive*** outcomes do not overlap with each other
  - *e.g.*, value of a playing card, letter grade in a class

- What could we use to represent these?

"elif" Statements

- The Python **elif** statement is used to handle additional exclusive conditions
  - Must have a "starting" **if** statement
  - The **elif** statements must have a ***condition***

short for "else if"

```
if <condition1>:
    <codeA statements>
elif <condition2>:
    <codeB statements>
```

Multi-Way Code Framework

```
if <condition1>:
    <codeA statements>
elif <condition2>:
    <codeB statements>
elif <condition3>:
    <codeC statements>
# more "elif" statements if needed
else:
    <codeD statements>
```

as many "**elif**" cases as are needed

"**else**" statement is optional

Multi-Way Decision Example

- A computer science professor gives a five-point quiz at the beginning of every class
- Possible grades are as follows:

5 points: A	3 points: C	1 point: F
4 points: B	2 points: D	0 points: F

- To print out the letter grade based on the raw points, what would the code need to look like?

Multi-Way Decision Solution

```
def main():
    score = int(input("Your quiz score out of 5: "))
    if score == 5:
        print("You earned an A")
    elif score == 4:
        print("You earned a B")
    elif score == 3:
        print("You earned a C")
    elif score == 2:
        print("You earned a D")
    else:
        print("You failed the quiz")

main()
```

Multi-Way Decision Solution

```
def main():
    score = int(input("Your quiz score out of 5: "))
    if score == 5:
        print("You earned an A")
    elif score == 4:
        print("You earned a B")
    elif score == 3:
        print("You earned a C")
    elif score == 2:
        print("You earned a D")
    else:
        print("You failed the quiz")

main()
```

these are five separate statements

since this is an `if-elif-else` block, only <u>one</u> of the five statements will be executed

Multi-Way Decision Solution

```
def main():
    score = int(input("Your quiz score out of 5: "))
    if score == 5:
        print("You earned an A")
    elif score == 4:
        print("You earned a B")
    elif score == 3:
        print("You earned a C")
    elif score == 2:
        print("You earned a D")
    else:
        print("You failed the quiz")

main()
```

How would you update this to handle floats?

Multi-Way Decision Solution

```
def main():
    score = float(input("Your quiz score out of 5: "))
    if score >= 5:
        print("You earned an A")
    elif score >= 4:
        print("You earned a B")
    elif score >= 3:
        print("You earned a C")
    elif score >= 2:
        print("You earned a D")
    else:
        print("You failed the quiz")

main()
```

How would you update this to handle floats?

What would happen if we just used "if" statements instead?

Multi-Way Decision Solution

```
def main():
    score = float(input("Your quiz score out of 5: "))
    if score >= 5:
        print("You earned an A")
    if score >= 4:
        print("You earned a B")
    if score >= 3:
        print("You earned a C")
    if score >= 2:
        print("You earned a D")
    else:
        print("You failed the quiz")

main()
```

What would print out for a score of 5?

You earned an A
You earned a B
You earned a C
You earned a D

Using only "**if**" statements give us the wrong answer!

Exclusive Conditions

- Using the **if-elif-else** block lets you have exclusive conditions more easily
  - No need to check `if score < 5 and score >= 4`
- Also, with a block, the `else` is only used if none of the other conditionals are `True`

- The **if-elif-else** block is evaluated from the top down, so the order of statements does matter

Nested Decision Structures

Nested Decision Structures

- Up until now, we have only used a single level of decision making
- What if we want to make decisions within decisions?
- These are called ***nested*** decision structures

Nested Decision Structures

- Python allows you to nest decision structures
  - As many levels deep as you want
  - Nesting can occur inside **`if`**, **`elif`**, or **`else`** statements
- Only "rule" is that every inside level must start with an "**`if`**"
  - Having matching **`elif`**s or an **`else`** is not required

Nested Decision Structure Example

- For example, we may
  - Ask the user if they have a pet
  - **`if`** they have a pet
    - Ask the user what type of pet
    - **`if`** they have a dog, take it for a walk
    - **`elif`** they have a cat, clean the litter box
    - **`else`** clean the cage/stable/tank

Nested Decision Structure Example

```
def main():
    ans = input("Do you have a pet? (yes/no) ")

    if ans != "no":
        pet = input("What kind of pet do you have? ")

        if pet == "dog":
            print("Take it for a walk")
        elif pet == "cat":
            print("Clean the litter box")
        else:
            print("Clean the cage/stable/tank")
main()
```

Nested Decision Structures Code

```
if <condition1>:
    if <condition2>:
        <codeA statements>
    elif <condition3>:
        <codeB statements>
    else:
        <codeC statements>
else:
    <codeD>
```

Nested Decision Structures Code

```
if <condition1>:
    if <condition2>:
        <codeA statements>
    elif <condition3>:
        <codeB statements>
    else:
        <codeC statements>
else:
    <codeD>
```

this is the main level of our program: an `if-else` block

this is the next level, inside the first `if` statement

codeA, codeB, and codeC are separate statements

since this is an `if-elif-else` block, only one of them will be executed

if condition1 was false, Python will go straight here and execute codeD

Nested Decision Structure Example

- You recently took a part-time job to help pay for your student loans at a local cell phone store

- If you sell at least $1000 worth of phones in a pay period, you get a bonus
  - Your bonus is 3% if you sold at least 3 iPhones, otherwise your bonus is only 2%

Nested Decision Solution

```
def main():
    totalSales = float(input("Please enter your total sales:"))

    if totalSales >= 1000.00:
        # only ask this if they are eligible for a bonus
        iPhonesSold = int(input("Enter the number of iPhones sold:"))

        if iPhonesSold >= 3:
            bonus = totalSales * 0.03
        else:
            bonus = totalSales * 0.02

        print("Your bonus is $", bonus)

    else:
        print("Sorry, you do not get a bonus this pay period.")
main()
```

Daily emacs Shortcut

- **CTRL+A**
  - Moves your cursor to the front of the line
  - (To remember: A is at the *front* of the alphabet)

- **CTRL+E**
  - Moves your cursor to the end of the line
  - (To remember: E stands for “end”)

Announcements

- HW 0 is due Friday, February 9th at 8:59:59 PM
- HW 1 will come out on Saturday, February 10th
  - Due by Friday (February 16th) at 8:59:59 PM
  - You must first complete the Syllabus and Course Website Quiz to see it
- Pre Lab 3 Quiz will come out Friday @ 10 AM
  - Must be completed by 10 AM Monday morning

Image Sources

- One way sign (adapted from):
  - https://pixabay.com/p-438122
- Splitting arrow:
  - https://pixabay.com/p-154512/
- Three decisions:
  - https://pixabay.com/p-1020289/
- Nest with eggs (adapted from):
  - https://pixabay.com/p-1485378