# CIS 125 Principles of Programming Logic

# Decision Structures and Boolean Logic

## An Introduction to Decision Structures

- Decision structures, e.g. aka branching or control structures.
- Allow a program to perform actions only under certain conditions (Boolean: true/false)
- Control the order in which a set of statements execute based on a decision.
- Up until now we have used sequence structures, with functions/modules.
- Decision structures are combined with sequence structures and functions/modules to create more intelligent programs (algorithms).

## Main types of Decision Statements in Programming Languages

1. IF (single IF statement; no elseif or else)
2. IF-ELSE
3. IF-ELSEIF-ELSE
4. IF-ELSEIF-ELSEIF …. ELSEIF-ELSE
5. Nested IF (an IF within an IF)
6. IF and IFELSE statements with logical operators
7. Case – Switch Statements (does not exist in Python)
8. Shortcut methods, e.g. ternary operator, etc.

## Boolean Expressions and Relational Operations

Boolean expressions are expressions that can only be evaluated as true or false

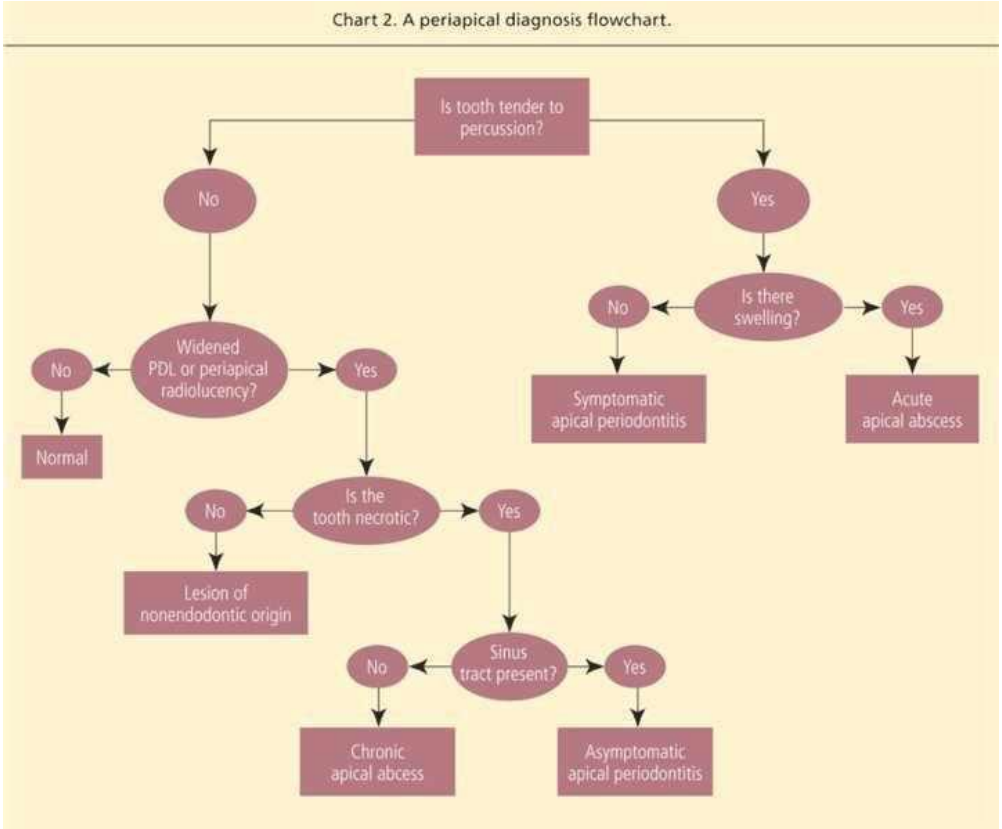
- **Summary of Python Comparison Operators**

| | |
|---|---|
| > | Greater than |
| < | Less than |
| >= | Greater than or equal to |
| <= | Less than or equal to |
| **==** | Equal to |
| != | Not equal to |

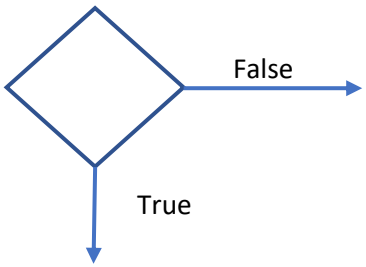
- **Assignment (=) is different than equal to (==)**
- Some languages use <> for not equal

**Flowchart with Decisions**

We will create a program in Homework #3 to diagnose a patient (below). Source: http://dentistryandmedicine.blogspot.com/2011/12/apical-diagnosis-flowchart.html




Typically, however, a decision is represented by a diamond in flowcharting.



**Example: Simple IF statement with a string**

```
employee1 = "Mary Smith"

if employee1 == "Mary Smith":
   print ("Hello Mary!")
```

**Notes**:

- Python requires specific indentation. This enforces good readability. You must be consistent with indentation in Python for programs to run. I use a tab for each level of indenting. One could use four or five spaces, for example, if one was consistent with this.
- *You use a double == with an IF* versus a single = used with variable assignments.

**Example: IF-ELSE with String User Input**

```
employee1 = "Mary Jones"

if employee1 == "Mary Smith":
   print ("Hello Mary!")
else:
   name1 = str(input("Who are you? "))
   print ("Hello", name1)
```

Sample output:

```
Who are you?   John
Hello John
```

**Note**:

- Notice how no { } needed. Indented lines belong to else.
- Colon must go at end of each if .. elif … else line
- IF statements use Boolean logic to decide which statements to run/execute
  - If it is TRUE that the value stored in the variable employee1 is equal to Mary Smith, then the lines intended under that CONDITION are run
  - ELSE – otherwise, run the lines under the ELSE statement

**Example: Single IF statement**

```
age = 19
if age >= 18:
    print("Your are old enough to vote.")
```

**Notes**:

- You must have at least an IF in an IF statement
- ELIF and ELSE's are *optional*, depending on needs of program
  - If you need them, you can have as *many ELIF's* as you want. You can have *only one ELSE* to catch cases where nothing above it was true

- If value stored in age variable is not greater than or equal to 18, then the lines under the IF do not run and the IF statement is over
- You do not place double quotes " " around *numbers* that are being evaluated.

**Example: Single IF statement**

```
age = 17
if age >= 18:
    print("Your are old enough to vote.")
print("Get out and vote.")
```

Output:

Get out and vote.

**Example: IF (decision) statement for grade**

```
grade = 84

if grade > 90:
    print ("You achieved an A")
elif grade > 80:
    print ("You achieved a B")
elif grade > 70:
    print ("You achieved a C")
elif grade > 60:
    print ("You achieved a D")
else:
    print ("You achieved an E")
```

Output:

You achieved a B

Important Note: you can only every have one IF and one ELSE. You can have as many ELSE IF's as the program needs. You must have an IF, everything else is optional.

**Example: Simple IF Statement with Multiple Lines of Code under If**

```
EmpName = "Amy Smith"
if EmpName == "Amy Smith":
    print("Welcome Amy")
    print("Today is your first day of work.")
    print("You will be attending an orienation session in the morning.")
    lunch = input("What would you like for lunch? ")
```

Note: You can have as many lines of any kind of code under the IF – just be sure to intent them in Python.

**Example: Several examples of IF (decision) statements**

```
message = "Hello"

if message == "Hello":
    name = "William"
    print(message + " " + name)

if message == "Hello" or message == "Welcome":
    name = "William"
    print(message + " " + name)
else:
    print("Goodbye")

if message == "Goodbye":
    name = "William"
    print("Goodbye", name)
```

Output:

Hello William
Hello William

## IFs with Logical Operators

**Python Logical Operators**

| | |
|---|---|
| and | or |

**Python Membership Operators**

| | |
|---|---|
| in | True if variable in specified sequence |
| not in | True if variable not in specified sequence |

**Example #7: IF-ELIF-ELSE**

```
zipcode = 48099
if zipcode == 48098:
    print("You vote in location 1.")
elif zipcode >= 48099 and zipcode <= 48101:
    print("You vote in location 2.")
elif zipcode >= 48102 and zipcode <= 48104:
    print("You vote in location 3.")
else:
    print("You vote in location 4.")
```

Output:

You vote in location 2.

**Example: IF-ELSE with IN operator and list**

```
zipcode_list1 = [48099,48100,48101,482012]
zipcode1 = 48099
if zipcode1 in zipcode_list1:
    print("You vote in location 1.")
else:
    print("You vote in location 4.")
```

Output:

You vote in location 1.

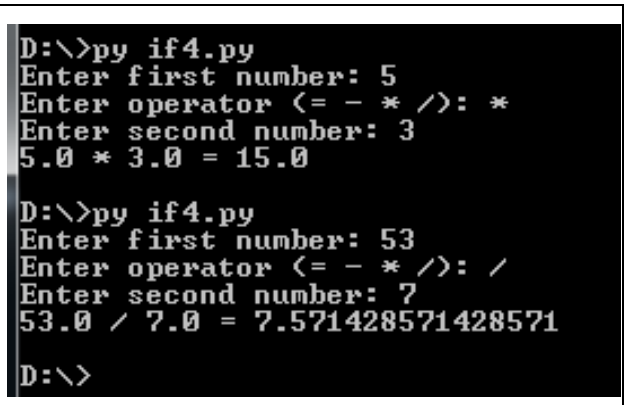
**Example: IF-ELSEIF – Calculator**

```
num1 = float(input("Enter first number: "))
operator = input("Enter operator (+- * /): ")
num2 = float(input("Enter second number: "))

if operator == "+":
        total = num1 + num2
elif operator == "-":
        total = num1 - num2
elif operator == "*":
        total = num1 * num2
elif operator == "/":
        total = num1 / num2

print (num1, operator, num2, "=", total)
```

**Output:**




**Example #10: IF statement with logical operators**

```
num1 = 4
num2 = 10

if num1 < 6 and num1 > 4:
   print ("num1 must be 5.")
elif num1 > 3 and num2 > 14:
   print ("num1 is greater than 3 and num2 is greater than 14.")
elif num1 > 3 or num2 > 14:
   print ("Either num1 is greater than 3 or num2 is greater than 14.")
else:
   print ("I'm not sure what num1 or num2 are.")
```

Output:

Either num1 is greater than 3 or num2 is greater than 14.

**Notes**:

- Double-quotes required around *strings* being compared. No double-quotes around *numeric* values being compared.
- *Else lines will never have a condition, e.g. else because they are not testing anything*
- IF statements often used for input validation, e.g. check if value between a range (range check).

**Example: IF statement with logical operators**

```
age1=77
if age1 < 12 or age1 > 65:
    print("You receive a discount on your meal.")
```

Output:

You receive a discount on your meal.

**Example: IF statement with logical operators**

```
age1=25
age2=21
age3=32
if age1 >= 18 and age2 >= 18 and age3 >=18:
    print("You are all old enough to vote.")
else:
    print("At least one of you is not old enough to vote.")
```

Output:

You are all old enough to vote.

**Example: IF statement with logical operators**

```
minitial="Elliot"
worth=35700000
company="Facebook"
title="CEO"

if (minitial == "Elliot" and worth > 30000000) or (title == "CEO" and company ==
"Facebook"):
    print("Hello Mr. Zuckerberg")
```

Output:

Hello Mr. Zuckerberg

**Example: IF statement with logical operators (alternate method to previous example)**

```
minitial="Elliot"
worth=35700000
company="Facebook"
title="CEO"

if (minitial == "Elliot" and worth > 30000000):
    print("Hello Mr. Zuckerberg")
elif (title == "CEO" and company == "Facebook"):
    print("Hello Mr. Zuckerberg")
```

**Example: IF statement with logical operators**

```
age1=77
day="Sunday"
if (age1 < 12 or age1 > 65) and day != "Friday":
       print("You receive a discount on your meal.")
```

Output:

You receive a discount on your meal.

**Example: IF statement with logical operators**

```
num1 = 4
num2 = 10

if num1 < 6 and num1 > 4:
   print ("num1 must be 5.")
elif num1 > 3 and num2 > 14:
   print ("num1 is greater than 3 and num2 is greater than 14.")
elif num1 > 3 or num2 > 14:
   print ("Either num1 is greater than 3 or num2 is greater than 14.")
else:
   print ("I'm not sure what num1 or num2 are.")
```

Output:

Either num1 is greater than 3 or num2 is greater than 14.

## Nested IFs

**Example: Nested IF with library import and wildcard search**

```
from fnmatch import fnmatch, fnmatchcase

employee1 = "Mary Johnson"
salary = 59000

if fnmatch(employee1, 'Mary*'):
   if salary >= 50000:
      print ("Mary, you make over $50,000.")
   else:
      print ("Mary.  You do not yet make $50,000.")
else:
   print ("I don't know who you are.")
```

Output:

Mary, you make over $50,000.

**Example: Nested IF**

```
salary = float(input("Enter your salary: "))
if salary >= 30000:
    yearsOnJob = float(input("Enter number of years at your current job: "))
    if yearsOnJob >= 2:
        print("You qualify for a loan.")
    else:
        print("You must be on the job at least 2 years to qualify for loan.")
else:
    print("You must earn at least $30,000 annually for this loan.")
```

Output (3 runs):

Enter your salary: 10000
You must earn at least $30,000 annually for this loan.

Enter your salary: 40000
Enter number of years at your current job: 1
You must be on the job at least 2 years to quality for loan.

Enter your salary: 400000
Enter number of years at your current job: 3
You qualify for a loan.

**Example: Nested IF statement example**

```
x = 10
y = 5
if x >= 10:
    if y > 5:
        print("One")
    else:
        print("Two")
else:
    if y > 5:
        print("Thee")
    else:
        print("Four")
```

What will the output be for the example above? _____

## IF Statements and Functions

**Example: Decision inside a function**

```
def calcBonus(units):
    if units > 1000:
        print("Your bonus will be 10%")
    elif units > 500:
        print("Your bonus will be 5%")
    elif units > 200:
        print("Your bonus will be 2.5%")

units = int(input("How many units did you sell this month? "))
calcBonus(units)
```

Output:

How many units did you sell this month? 700
Your bonus will be 5%

**Example: IF-ElIF-ELSE Statement**

```
class_type = input("Please enter the class type code: ")

if class_type == "D":
    print("Your class type is day")
elif class_type == "E":
    print("Your class type is evening")
elif class_type == "O":
    print("Your class type is online")
elif class_type == "H":
    print("Your class type is hyrid")
else:
    print("Invalid class code")
```

**Example: Variation of Previous Example with Functions and IF-ElIF-ELSE Statement**

```
def getInput():
    class_type = input("Please enter the class type code: ")
    return class_type

def displayClassType(class_type):
    if class_type == "D":
        print("Your class type is day")
    elif class_type == "E":
        print("Your class type is evening")
    elif class_type == "O":
        print("Your class type is online")
    elif class_type == "H":
        print("Your class type is hybrid")
    else:
        print("Invalid class code")

class_type = getInput()
displayClassType(class_type)
```

**Example: Variation of Previous Example with Functions and IF-ElIF-ELSE Statement**

```
def getInput():
    class_type = input("Please enter the class type code: ")
    return class_type

def classTypeDay():
    print("Your class type is day")

def classTypeEvening():
    print("Your class type is evening")

def classTypeOnline():
    print("Your class type is online")

def classTypeHybrid():
    print("Your class type is hybrid")

# Main Program
class_type = getInput()
if class_type == "D":
    classTypeDay()
elif class_type == "E":
    classTypeEvening()
elif class_type == "O":
    classTypeOnline()
elif class_type == "H":
    classTypeHybrid()
else:
    print("Invalid class code")
```

**Example: Program Menu with Decision and Functions**

```
def printCheck():
    print("Print checks")

def enterHours():
    print("Enter hours")


# Main
print("Main Menu\n--------------")
print("1. Print check")
print("2. Enter employee hours")
print("3. Exit")
choice = input("Please enter choice: ")
if choice == "1":
    printCheck()
elif choice == "2":
    enterHours()
elif choice == "3":
    print("Goodbye")
```

**Example: IF Statements and Muti0ple Functions with Menu**

```
def displayMenu():
    print("Main Menu")
    print("---------")
    print("1. Look-Up Employee")
    print("2. Update Employee Information")
    print("3. Print Paycheck")
    print("4. Exit")
    choice = input("Please enter choice: ")
    return choice

def employeeLookUp():
    print("Look-Up Employee")
    employeeID = input("Enter Employee ID: ")
    # Code to query employee ID
    #
    #
    print("Employee ID", employeeID, "information: ")

def employeeUpdate():
    print("Update Employee Information")

choice = displayMenu()
if choice == "1":
    employeeLookUp()
elif choice == "2":
    employeeUpdate()
```

**Example: Math Program with Decisions and Functions**

```
def addNums(num1,num2):
    total = num1 + num2
    print("The sum of the two numbers is %.2f" % total)

def diffNums(num1,num2):
    total = num1 - num2
    print("The difference between the two numbers is %.2f" % total)

# Maun
num1 = float(input("Please enter number #1: "))
num2 = float(input("Please enter number #2: "))
addNums(num1,num2)
diffNums(num1,num2)
```

Output:

Please enter number #1: 6.5
Please enter number #2: 3
The sum of the two numbers is 9.50
The difference between the two numbers is 3.50

**Example: Grade Calculator**

```
def displayGrade(score):
    if score > 100:
        print("You achieved an A+ in the class.")
    elif score > 90:
        print("You achieved an A in the class.")
    elif score > 80 :
        print("You achieved an B in the class.")
    elif score > 70 :
        print("You achieved an C in the class.")
    elif score > 60 :
        print("You achieved an D in the class.")
    else:
        print("You achieved an E in the class.")


def calcGrade():
    exam1 = float(input("Enter your score for Exam #1: \t\t"))
    exam2 = float(input("Enter your score for Exam #2: \t\t"))
    exam3 = float(input("Enter your score for Exam #3: \t\t"))
    score = (exam1 + exam2 + exam3) / 3
    return score

score = calcGrade()
displayGrade(score)
```

## Alternate IF Statement Examples

**Example #25: Alternate if / decision format**

```
a = 3
b = 2
x = 10
y = 20
result = x if a > b else y
print(result)
```

Output:

10

**Example: Alternate if / decision format**

```
x = 10
print(0 if x == 9 else 1)
```

Output:

```
1
```

**Example: Alternate if / decision format**

```
age = int(input("Enter your age: "))
print('You are not able to vote yet.' if age < 18 else 'You can vote.')
```

Output:

```
Enter your age: 22
You can vote.
```

**Example: An if statement in a function return**

```
def calcBonus(units):
   return .10 if units > 500 else .025

units = int(input("How many units did you sell this month? "))
bonus = calcBonus(units)
print("Your bonus is ", bonus*100, "%.")
```

Output:

```
How many units did you sell this month? 900
Your bonus is  10.0 %.
```

## The Case Structure

- The case (switch) statement is another way to program decisions.
- Unlike many of programming languages, **Python does not have a Case – Switch statement**. They say an IF-ELSEIF-ELSEIF-ELSE can do the same thing as a case. Some programmers have created a switch like statement in Python using Python dictionary mapping. https://docs.python.org/2/faq/design.html#why-isn-t-there-a-switch-or-case-statement-in-python
- Replaces if-elseif-elseif-else statements.
- Pseudocode example:

```
select   class_type
     case 'D':
              display "Day"
     case 'E':
              display "Evening"
     case 'O':
              display "Online"
     default:
              display "Invalid Selection"
end-select
```

## Practice: Boolean Expressions and Relational and Logical Operations

1. Complete the following table, listing either True or False:

| Conditional Expression | True or False |
|---|---|
| 100 > 77 | TRUE |
| 44 < 44 | FALSE |
| 33 <= 55 | TRUE |
| 6 * 12 < 3 + 7 % 2 | FALSE |
| "apples" < "pears" | TRUE |
| 'Y' > 'B' | TRUE |

2. Complete the following table, listing either True or False based on the comparison of relational two expressions surrounding an **OR** situation

| Expression 1 | Expressions 2 | Result (True or False) |
|---|---|---|
| T | T | TRUE |
| T | F | TRUE |
| F | T | TRUE |
| F | F | FALSE |

3. Complete the following table, listing either True or False based on the comparison of relational two expressions surrounding an **AND** situation

| Expression 1 | Expressions 2 | Result (True or False) |
|---|---|---|
| T | T | TRUE |
| T | F | FALSE |
| F | T | FALSE |
| F | F | FALSE |

4. Complete the following table assuming A = 5 and = 8:

| Compound Condition | Result (True/False) |
|---|---|
| A >= 5 AND B >= 8 | TRUE |
| A==3 AND B==11 | FALSE |
| A==3 AND B==8 | FALSE |
| A>3 AND B<12 | TRUE |
| A>=5 AND B<8 | FALSE |
| A==4 OR B==9 | FALSE |
| A==8 OR B==8 | TRUE |
| A>4 OR B<3 | TRUE |
| A>=5 OR B<2 | TRUE |
| (A == 4 OR B == 3) OR (A >= 6 OR B >= 8) | TRUE |
| (A == 4 OR B == 3) AND (A >= 6 OR B >= 8) | FALSE |