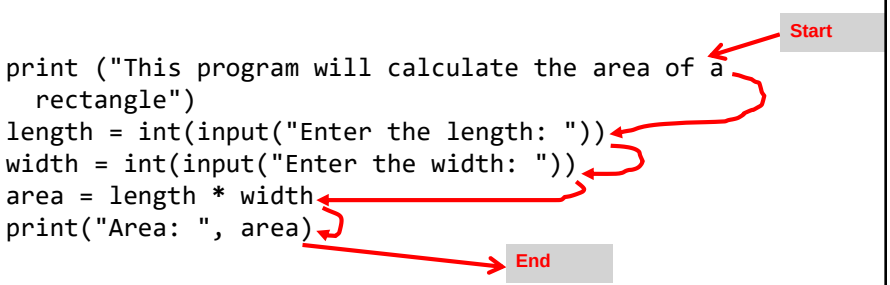
Branching In Python: Part 1

- IF
- IF-ELSE
- Logic: AND, OR, NOT

James Tam

Recap: Programs You've Seen So Far Produces Sequential Execution



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Programming: Decision Making Is Branching

- Decision making is choosing among alternates (branches).
- Why is it needed?
  - When alternative courses of action are possible and each action may produce a different result.
- In terms of a computer program the choices are stated in the form of a question that only yield an answer that is either true or false
  - Although the approach is very simple, modeling decisions in this fashion is a very useful and powerful tool.

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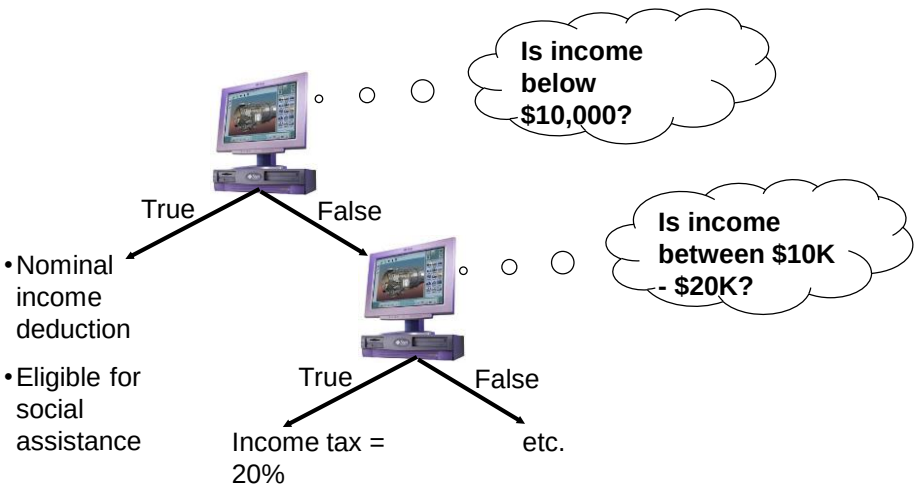
High Level View Of Decision Making For The Computer



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How To Determine If Branching Can Be Applied

- Under certain circumstances or conditions events will occur (the program reacts in a certain way if certain conditions have been met).
  - The branch determines if the event occurred and reacts accordingly.
- Examples:
  - If users who don't meet the age requirement of the website he/she will not be allowed to sign up (conversely if users do meet the age requirement he/she will be allowed to sign up).
  - If an employee is deemed as too inexperienced and too expensive to keep on staff then he/she will be laid off.
  - If a person clicks on a link on a website for a particular location then a video will play showing tourist 'hot spots' for that location.
  - If a user enters invalid age information (say negative values or values greater than 114) then the program will display an error message.

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Decision-Making In Programming (Python)

- Decisions are questions with answers that are either true or false (Boolean expressions) e.g., Is it true that the variable 'num' is positive?
- The program may branch one way or another depending upon the answer to the question (the result of the Boolean expression).
- Decision making/branching constructs (mechanisms) in Python:
  - `If` (reacts differently only for true case)
  - `If-else` (reacts differently for the true or false cases)
  - `If-elif-else` (multiple cases possible but only one case can apply, if one case is true then it's false that the other cases apply)

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New Terminology

- **Boolean expression**: An expression that must work out (evaluate to) to either a true or false value.
  - e.g., it is over 45 Celsius today
  - e.g., the user correctly entered the password
- **New term, body**: A block of program instructions that will execute under a specified condition (for branches the body executes when the Boolean expression evaluates to/works out to true)

```
name=input("Name: ")
print(name)
```

This/these instruction/instructions run when you give the Python interpreter the name of a file, the 'body' of the Python program runs

  - Style requirement
    - The 'body' is indented (4 spaces)
    - Don't use tabs (tabs won't consistently indent across computers/programs)

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New Terminology (2)

- **Operator/Operation**: action being performed
- **Operand**: the item or items on which the operation is being performed.

Math Examples:

```
2 + 3
2 * (-3)
```

Examples which produce a Boolean

```
x > 2
username == "tam"
```

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Allowable Operands For Boolean Expressions

Format:

```
(operand     relational operator    operand):
```

Example:

```
(age >= 18):
```

Some operand types

- integer
- floats (~real)
- String
- Boolean (True or False)
  - E.g. `runProgramAgain = False`

Make sure that you are comparing operands of the same type or at the very least they must be comparable!

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Allowable Relational Operators For Boolean Expressions

```
if (operand     relational operator     operand) then
```

Python operator	Mathematical equivalent	Meaning	Example
<	<	Less than	5 < 3
>	>	Greater than	5 > 3
==	=	Equal to	5 == 3
<=	≤	Less than or equal to	5 <= 5
>=	≥	Greater than or equal to	5 >= 4
!=	≠	Not equal to	x != 5

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Note On Indenting

- Indenting can make it easy to see structure (good style)

Notes 'Introduction to computers' CPSC 203

1. Magnetic
   - -Hard drives (includes older types of drives: floppy, zip)
2. Optical
   - CD
   - DVD
3. Solid State
   - USB 'thumb'/'flash' drives
   - Solid state hard drives (SSD)

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Note On Indenting (2)

- In Python indenting is mandatory in order to determine which statements are part of a body (**syntactically required** in Python).

```
# Single statement body
if (num == 1):
    print("Body of the if")
print("After body")

# Multi-statement body (program 'if2.py')
taxCredit = 0
taxRate = 0.2
income = float(input("What is your annual income: "))
if (income < 10000):
     print("Eligible for social assistance")
     taxCredit = 100
tax = (income * taxRate) - taxCredit
print("Tax owed $%.2f" %(tax))
```

```
What is your annual income: 1000
Eligible for social assistance
Tax owed $100.00
```

```
What is your annual income: 10001
Tax owed $2000.20
```

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Note On Indenting (3)

- A "sub-body" (`IF`-branch) is indented by an additional 4 spaces (8 or more spaces) if one `IF`-branch is inside the body of another `IF`-branch (this is called 'nesting' – more details later).
- Again you should **NOT use tabs** for indenting what looks neatly and consistently indented with one editor or operating system could be a mess in other cases:
  - If you write programs on different platforms (e.g. using a UNIX editor in the lab and Notepad at home).
  - When your marker views your assignment or project.

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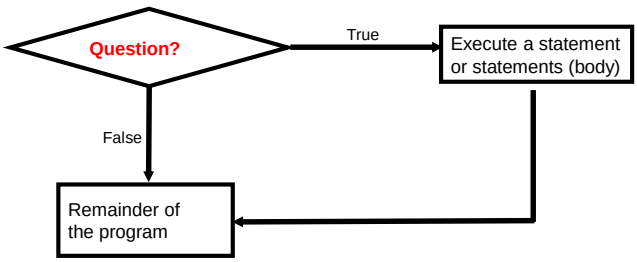
Decision Making With An 'If'



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The 'If' Construct

- Decision making: checking if a condition is true (in which case something should be done).
- **Format:**

```
(General format)
 if (Boolean expression):
     body
(Detailed structure)
if (<operand> <relational operator> <operand>):
     body
```

Boolean expression

Note: Indenting the body is mandatory!

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The 'If' Construct (2)

- **Example (`1if1.py`):**

  Learning objective of example: program executes a statement when a Boolean expression evaluates to true.

```
age = int(input("Age: "))
if (age >= 18):
   print("You are an adult")
```

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Common Mistake

- Do not confuse the equality operator '==' with the assignment operator '='.
- **Example (Python syntax error)**[1]:

```
if (num = 1):    # Not the same as   if (num == 1):
```

To be extra safe some programmers put unnamed constants on the left hand side of an equality operator (which always/almost always results in a syntax error rather than a logic error if the assignment operator is used in place of the equality operator).

- A way of producing syntax rather than a logic error:

```
if (1 = num)
```

1 This not a syntax error in all programming languages so don't get complacent and assume that the language will automatically "take care of things" for you.

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A Similar Mistake

- **Example (Python syntax error, used to be a logic error)**:

`num == 1` Not the same as `num = 1`

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An Application Of Branches

- Branching statements can be used to check the validity of data (if the data is correct or if the data is a value that's allowed by the program).
- **General structure**:

```
if (error condition has occurred):
    React to the error (at least display an error message)
```

- **Example**:

```
if (age < 0):
    print("Age cannot be a negative value")
```

JT's tip: if data can only take on a certain value (or range) do not automatically assume that it will be valid. Check the validity of range before proceeding onto the rest of the program.

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Decision Making With An '`If`': Summary

- Used when a question (Boolean expression) evaluates only to a true or false value (Boolean):
  - If the question evaluates to true then the program reacts differently. It will execute the body after which it proceeds to the remainder of the program (which follows the if construct).
  - If the question evaluates to false then the program doesn't react differently. It just executes the remainder of the program (which follows the if construct).

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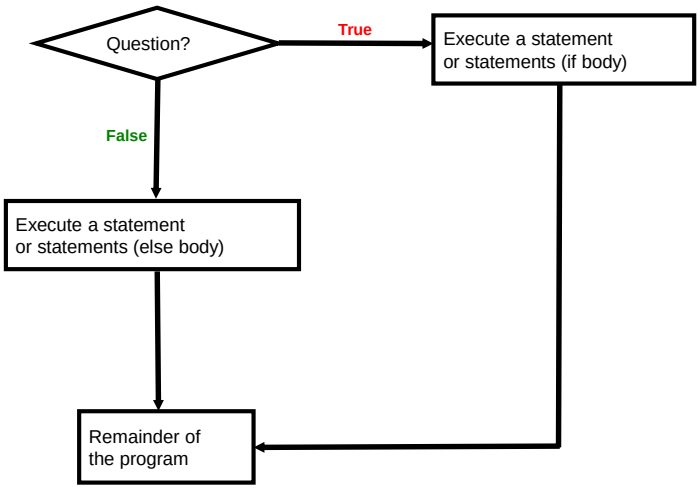
Decision Making With An 'If-Else'



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The If-Else Construct

- Decision making: checking if a condition is true (in which case something should be done) but unlike '`if`' *also reacting if the condition is not true (false).*
- **Format:**

```
if (operand  relational operator  operand):
    body of 'if'
else:
    body of 'else'
additional statements
```

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`If-Else` Construct (2)

- **Program name:** `2if_else1.py`
  - Learning objective of example: program executes one body when a Boolean expression evaluates to true and another when it's false.
- **Partial example:**

```
if (age < 18):
    print("Not an adult")
else:
    print("Adult")
print("Tell me more about yourself")
```

```
[csc branches 13 ]> python if_else1.py
How old are you? 17 <-- If case
Not an adult
Tell me more about yourself
[csc branches 14 ]>
[csc branches 14 ]> python if_else1.py
How old are you? 27 <-- Else case
Adult
Tell me more about yourself
[csc branches 15 ]>
```

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Lesson: Read Things The Way *They're Actually Stated* (Instead of How You Think They're Stated)

You this read wrong

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Lesson: Read Things The Way *They're Actually Stated* (Instead of How You Think They're Stated)

- **Example: Actual Code (previous version <=2012)**

  Learning objective of example: seeing alternative implementations of a program that produce the same result.

```
if (age >= 18):
    print("Adult")
else:
    print("Not an adult")
print("Tell me more about yourself")
```

JT's note: this version of the program is logically equivalent (does the same thing) as the version you just saw. For practice trace by hand both versions to convince yourself that this is the case. Then run both versions to verify.

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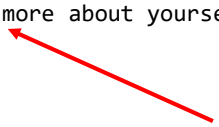
Lesson: Read Things The Way They're Actually Stated (Instead of How You Think They're Stated)

- **Example:** How some students interpreted the code (optical illusion?)
  - Learning objective of example: trace a program the way it is actually specified rather than how you think it is specified.

```
if (age >= 18):
    print("Adult")
else:
    print("Not an adult")
    print("Tell me more about yourself")
```



JT's tip: one way of making sure you read the program code the way it actually is written rather than how you think it should be is to take breaks from writing/editing

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`If-Else` Example

- **Program name:** 3`if_else2.py`
  - Learning objective of example: defining the bodies of an `IF`-case and an `ELSE`-case with multiple statements.
- **Partial example:**

```
if (income < 10000):
    print("Eligible for social assistance")
    taxCredit = 100
    taxRate = 0.1
else:
    print("Not eligible for social assistance")
    taxRate = 0.2
tax = (income * taxRate) - taxCredit
```

```
[csc branches 16 ]> python if_else2.py
What is your annual income: 1000
Eligible for social assistance
Tax owed $0.00
```

```
[csc branches 17 ]> python if_else2.py
What is your annual income: 10000
Not eligible for social assistance
Tax owed $2000.00
```

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Quick Summary: `If` Vs. `If-Else`

- If:
  - Evaluate a Boolean expression (ask a question).
  - If the expression evaluates to true then execute the 'body' of the `if`.
  - No additional action is taken when the expression evaluates to false.
  - Use when your program is supposed to react differently only when the answer to a question is true (and do nothing different if it's false).
- If-Else:
  - Evaluate a Boolean expression (ask a question).
  - If the expression evaluates to true then execute the 'body' of the `if`.
  - If the expression evaluates to false then execute the 'body' of the `else`.
  - That is: *Use when your program is supposed to react differently for both the true and the false cases*.

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Logical Operations

- There are many logical operations but the three most commonly used in computer programs include:
  - Logical AND
  - Logical OR
  - Logical NOT

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Logical AND

- The popular usage of the logical AND applies when *ALL* conditions must be met.
- Logical AND can be specified more formally in the form of a truth table.

Truth table (AND)		
C1	**C2**	**C1 AND C2**
False	False	False
False	True	False
True	False	False
True	*True*	*True*

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Logical AND: Three Input Truth Table

Truth table			
C1	**C2**	**C3**	**C1 AND C2 AND C3**
False	False	False	False
False	False	True	False
False	True	False	False
False	True	True	False
True	False	False	False
True	False	True	False
True	True	False	False
True	*True*	*True*	*True*

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Evaluating Logical AND Expressions

- In class:
  - False **AND** True **AND** True
- Extra for you to do:
  - True **AND** True **AND** True
  - True **AND** True **AND** True **AND** False

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Logical OR

- The correct everyday usage of the logical OR applies when *ATLEAST* one condition must be met.

Truth table		
C1	**C2**	**C1 OR C2**
False	*False*	*False*
False	True	True
True	False	True
True	True	True

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Logical OR: Three Input Truth Table

Truth table			
C1	**C2**	**C3**	**C1 OR C2 OR C3**
False	*False*	*False*	*False*
False	False	True	True
False	True	False	True
False	True	True	True
True	False	False	True
True	False	True	True
True	True	False	True
True	True	True	True

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Evaluating Logical OR Expressions

- In class:
  - False **OR** True **OR** True
- Extra for you to do:
  - True **OR** True **OR** True
  - False **OR** False **OR** False **OR** True

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Logical NOT

- The everyday usage of logical NOT negates (or reverses) a statement.
- The truth table for logical NOT is quite simple:

Truth table	
S	**Not S**
False	True
True	False

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Evaluating More Complex Logical Expressions

- Order of operation (left to right evaluation if the 'level' is equal)
  1. Brackets (inner first)
  2. Negation
  3. AND
  4. OR

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Evaluating More Complex Logical Expressions

- In class:
  - True **OR** False **AND** False
  - (True **OR** False) **AND** False
  - **NOT** False
  - **NOT NOT** False
- Extra for you to do:
  - **NOT** (False **OR** True) **OR** True
  - (False **AND** False) **OR** (False **AND** True)
  - **NOT NOT NOT NOT** True
  - **NOT NOT NOT** False

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Student Exercise: Extra Practice

- (From "Starting out with Python (2nd Edition)" by Tony Gaddis)
  Assume the variables a = 2, b = 4, c = 6
  For each of the following conditions indicate whether the final value is true or false.

Expression	Final result
a == 4 or b > 2	
6 <= c and a > 3	
1 != b and c != 3	
a >-1 or a <= b	
not (a > 2)	

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After This Section You Should Now Know

- What are the three decision making constructs available in Python:
  - `If`
  - `If-else`
  - `If-elif-else`
  - How does each one work
  - When should each one be used
- Three logical operations:
  - AND
  - OR
  - NOT
- How to evaluate and use decision making constructs:
  - Tracing the execution of simple decision making constructs

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After This Section You Should Now Know (2)

- How the bodies of the decision making constructs are defined:
  - What is the body of a decision making construct
  - What is the difference between decision making constructs with simple bodies and those with compound bodies
- What is an operand
- What is a relational operator
- What is a Boolean expression
- How multiple expressions are evaluated and how the different logical operators work

James Tam

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