Warm Up

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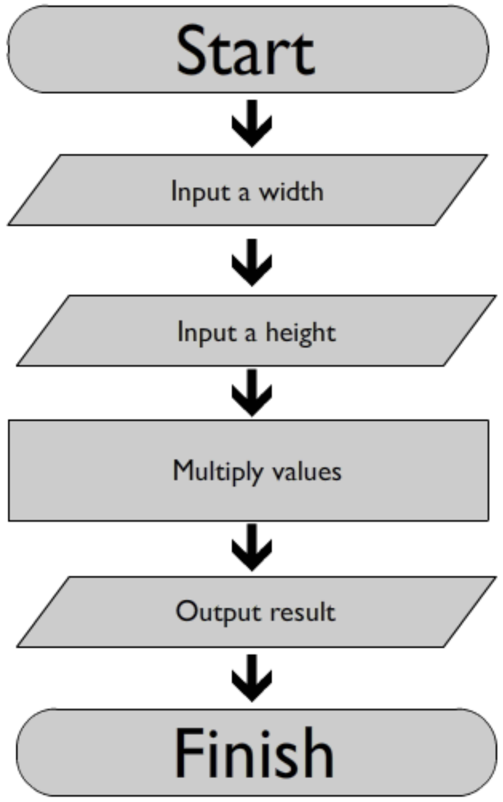
Decision Structures & Boolean Logic

CSCI-UA.002-006

Sequence Structures

- Sequence structures are sets of statements that execute in the order in which they appear
- Unfortunately not all programs can be written this way, as there are certain times when we need to deviate from a linear structure and adapt our program based on information provided.



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Example: Calculating Overtime Pay

- If a worker works more than 40 hours in a week he or she is entitled to overtime pay.
- Overtime pay is calculated at the rate of 1.5 times the worker's hourly rate.
- This additional rate is only applied to hours worked above the 40 hour limit.

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Example: Calculating Overtime Pay

- Input: Hourly rate of pay
- Input: Number of hours worked in 1 week

- Process: If the hours worked is less than 40, simply multiply hourly rate by hours worked
- Process: If the hours worked is greater than 40:
  - Multiply hourly rate by hours worked for 40 hours.
  - Subtract 40 from the the total hours to obtain the overtime hours
  - Multiply overtime hours by 1.5 times the rate of pay
  - Add overtime pay to base pay

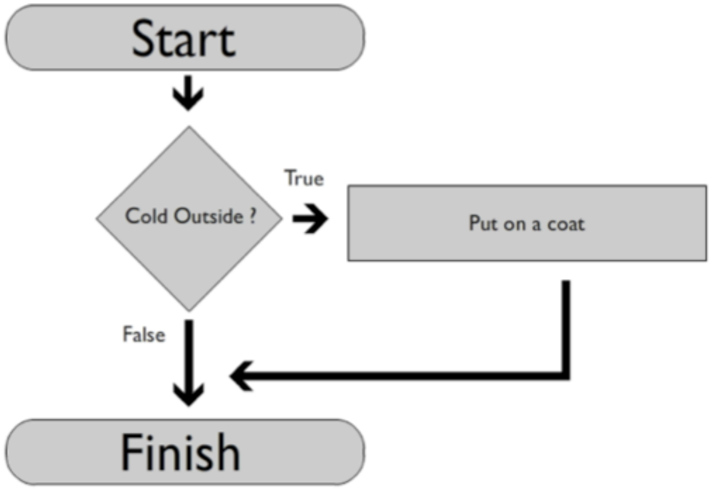
- Output: Total Pay

The Selection Statement

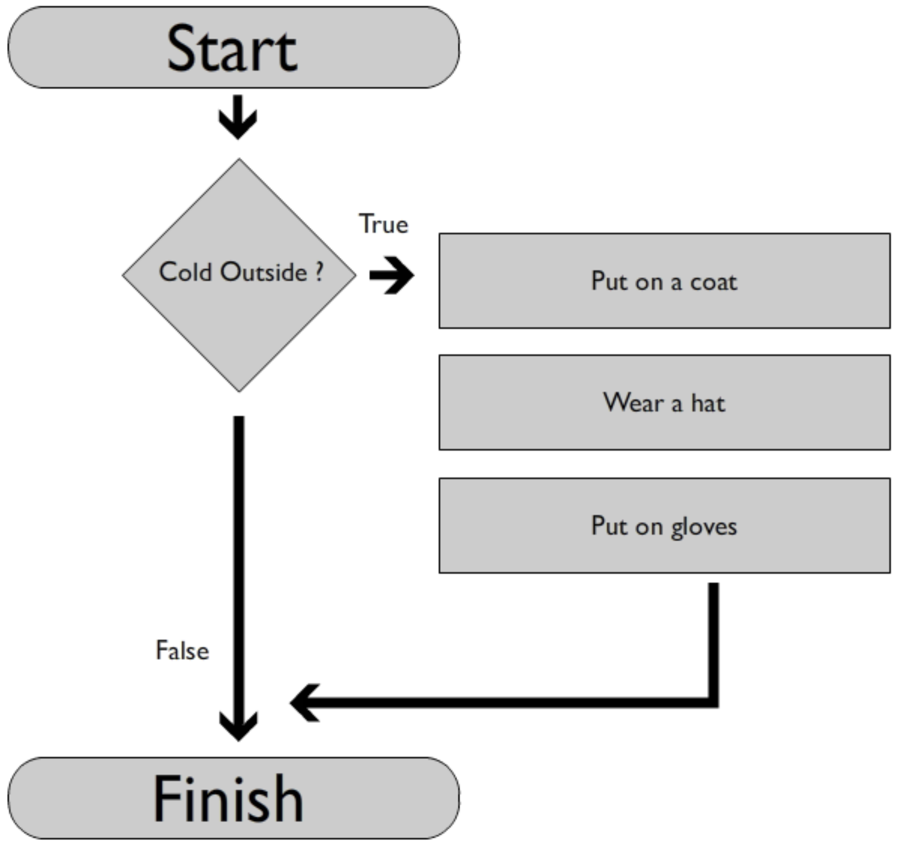
- Allows your program to “ask a question” and respond accordingly.
- Simplest form – perform an action only if a certain condition exists
- If the condition is not met, then the action is not performed

The Selection Statement

- In this program we begin by asking a question – "is it cold outside?"
- If the answer to this question is yes (aka "True") then we can execute an alternate set of commands
- Otherwise we can continue with the program as-is



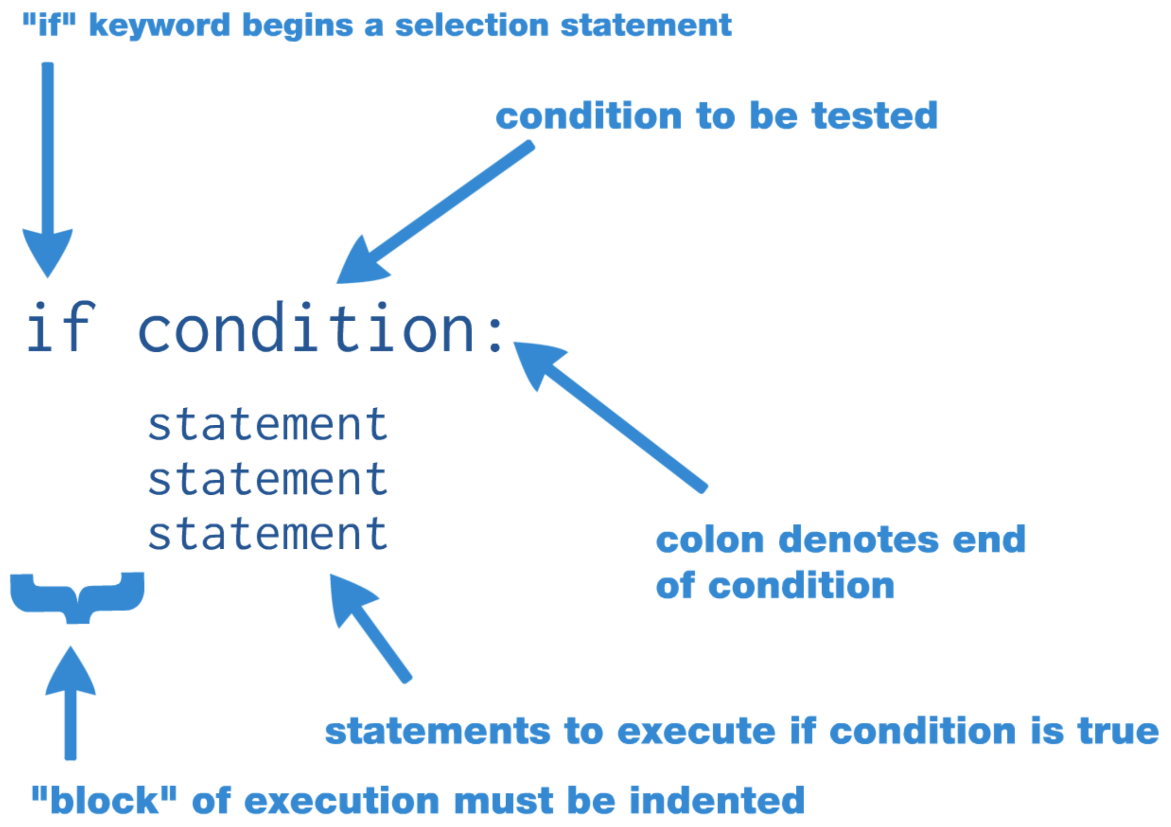
+ The Selection Statement



+ Selection Statements in Python

```
if condition:
    statement
    statement
    statement
```

Selection Statements in Python



```
if condition:
    statement
    statement
    statement
```

"if" keyword begins a selection statement
condition to be tested
colon denotes end of condition
statements to execute if condition is true
"block" of execution must be indented

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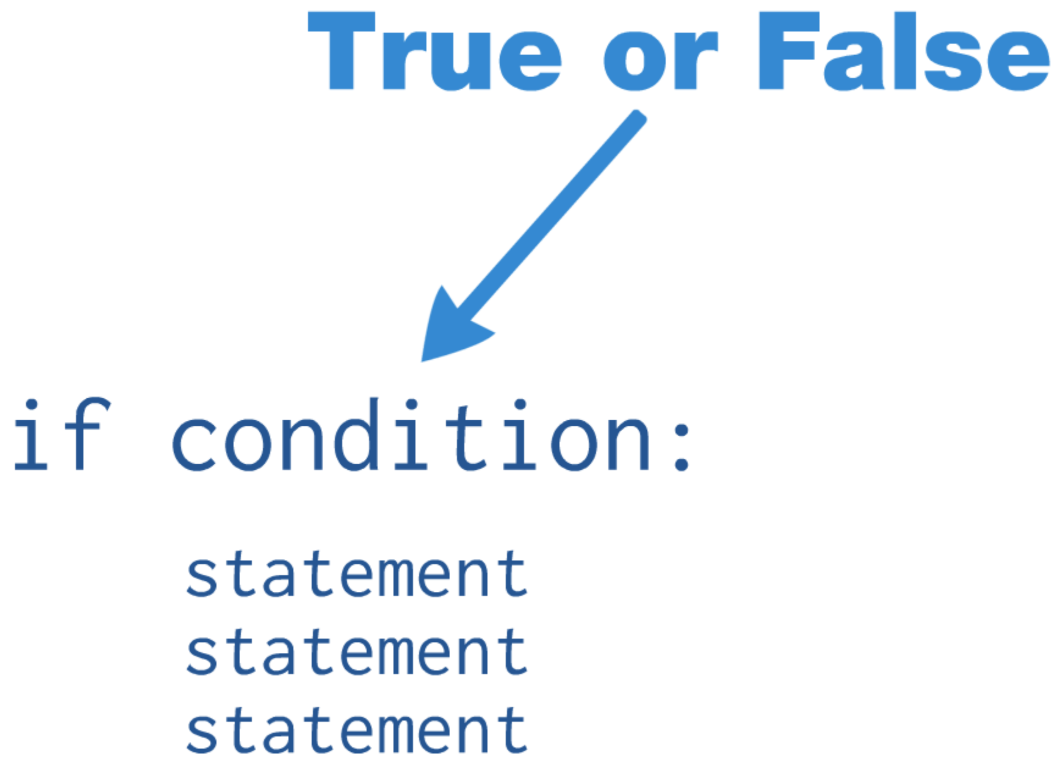
Boolean Expressions

Writing a condition

- The trick to writing a selection statement is in constructing a condition that matches the question you are trying to ask the computer
- All selection statements must have a condition to "test"
- **Think of conditions as "yes or no" questions.** They can only be answered by one of two options – "True" or "False"

Boolean Expressions



```
if condition:

    statement
    statement
    statement
```

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Boolean Expressions

- Named after George Boole, a 19th century English philosopher and mathematician
- Boole developed a system of mathematics that allows us to work with the abstract concepts of "true" and "false"
- Boole is considered one of the founders of modern computer science, as his work underpins the way in which modern computers process binary data

Writing a Boolean Expression

- Boolean expressions can be used as the condition in an "if" statement
- They are generally formed using "**relational operators**" which allow you to test to see whether a specific relationship exists between two (or more) values

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Relational Operators

```
a > b         # is a greater than b ?

a < b         # is a less than b ?

a == b        # is a equal to b ?

a <= b        # is a less than OR
              # equal to b ?

a >= b        # is a greater than OR
              # equal to b ?
```

Writing a Boolean Expression

- ALL Boolean expressions boil down to "True" or "False"
- Programmers often say that the expression "evaluates" to "True" or "False"

Writing a Boolean Expression

```
pen = 10

sword = 7


if pen > sword:                    # pen > sword

  print ('the pen is               # 10 > 7
  mightier than the
  sword!')                         # True
```

+
Let's Evaluate!

```
# given these variables

a = 99

b = 7

c = -5

d = 92
```

```
# evaluate these expressions

a > b

b < c

b >= c

c <= d

a == b + d

d <= a + c

c != b
```

Boolean Operator Tips

- Don’t confuse “==“ with “=“
  - “=“ is used for assigning values to variables
  - “==“ is used for testing to see if two values are identical
- Use “!=“ if you want to test if two values are different
- The “<=“ and “>=“ operators test for more than one relationship
  - “<=“ tests to see if a value is less than OR equal to another
  - “>=“ tests to see if a value is greater than OR equal to another

Let's write some programs!

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Programming Challenge: Freezing / Boiling Guppies

- Guppies are hardy fish, but they can't live in all water temperatures.
- The acceptable range for guppies is between 72 and 86 degrees Fahrenheit.
- Write a program that asks the user for a temperature. Then display one of two messages based on the information provided:
  - You're going to freeze your guppy!
  - You're going to boil your guppy!

Programming Challenge: Number Guessing Game

- Ask the user to guess a number between 1 and 10. Assume they will enter an Integer.
- Pick a number between 1 and 10 that is your "secret" number (for example, 5)
- If the user types in your secret number, tell them that they win!
- If the user types in a number less than or greater than your secret number, tell them that they're either above or below the number and to try again

Programming Challenge: Calculating a bonus

- You're the manager of a large, distributed sales force
- You want to create an easy to use tool that will allow your sales staff to do the following:
  - Input their monthly sales amount
  - Determine if they made their monthly quota of $10,000
  - If they made their quota, they are eligible for a bonus of $500
  - If they made their quota, they should receive a "Good Job!" message
  - At the end of the program you should print out how much their bonus will be ($0 or $500)

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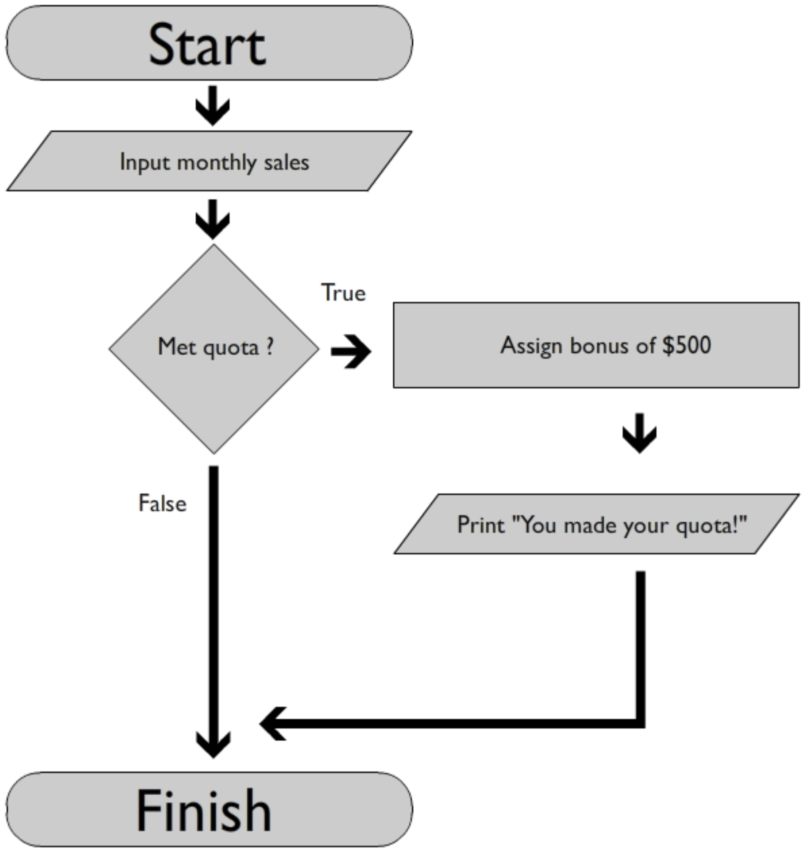
Programming Challenge: Calculating a bonus



Extension

- All sales people should receive 1% commission on their sales
- If a sales person made over 50,000, they should receive 5% commission on their sales (instead of 1%) – this is in addition to their $500 bonus for making their quota
- Print out their total take-home amount (bonus + commission) at the end of the program

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Selection Statements in the Wild!

- How are selection statements used in ATM machines?
- How many selection statements can you count from your last ATM transaction?

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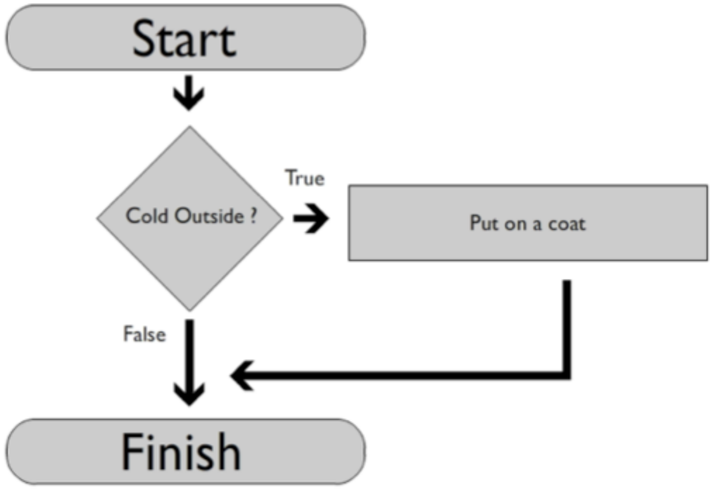
The IF – ELSE structure

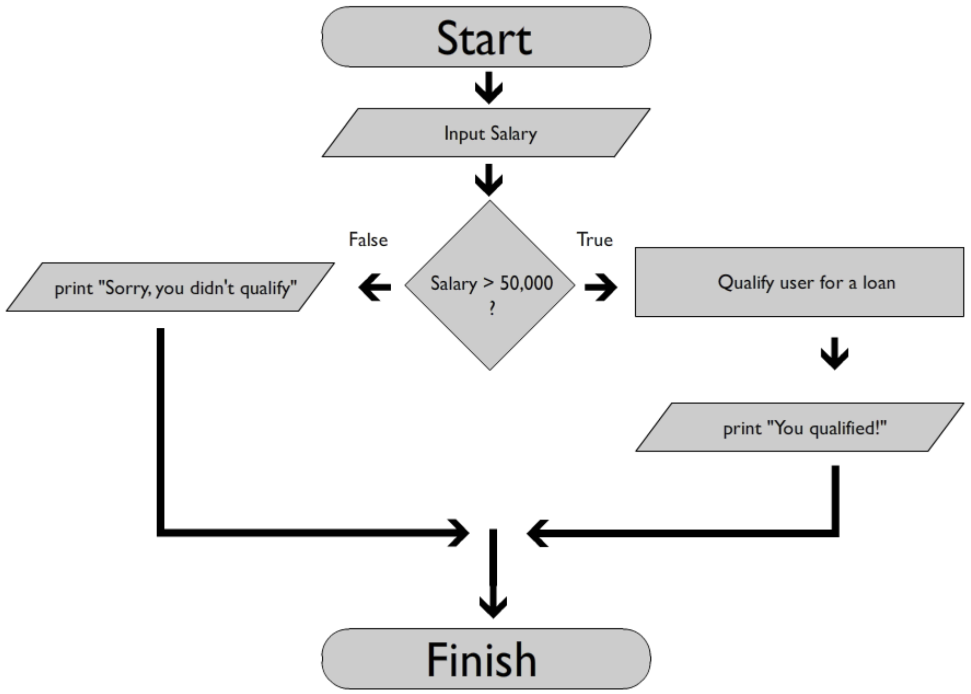
Simple Selection Statements

- The selection statements we have been writing so far have only allowed us to create a single alternate branch of execution
- There are many times when we need to create multiple branches of execution based on the value of a Boolean expression



The IF-ELSE structure

- The IF-ELSE structure allows you to perform one set of statements if a condition is true, and another if it is false



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The IF-ELSE structure

```
if temperature < 32:
  print (“it’s freezing outside!”)

else:
  print (“it’s not so bad outside …”)
```

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Programming Challenge: Calculating Overtime Pay

- If a worker works more than 40 hours in a week he or she is entitled to overtime pay.
- Overtime pay is calculated at the rate of 1.5 times the worker's hourly rate.
- This additional rate is only applied to hours worked above the 40 hour limit.

Programming Challenge: Calculating Overtime Pay

- Input: Hourly rate of pay
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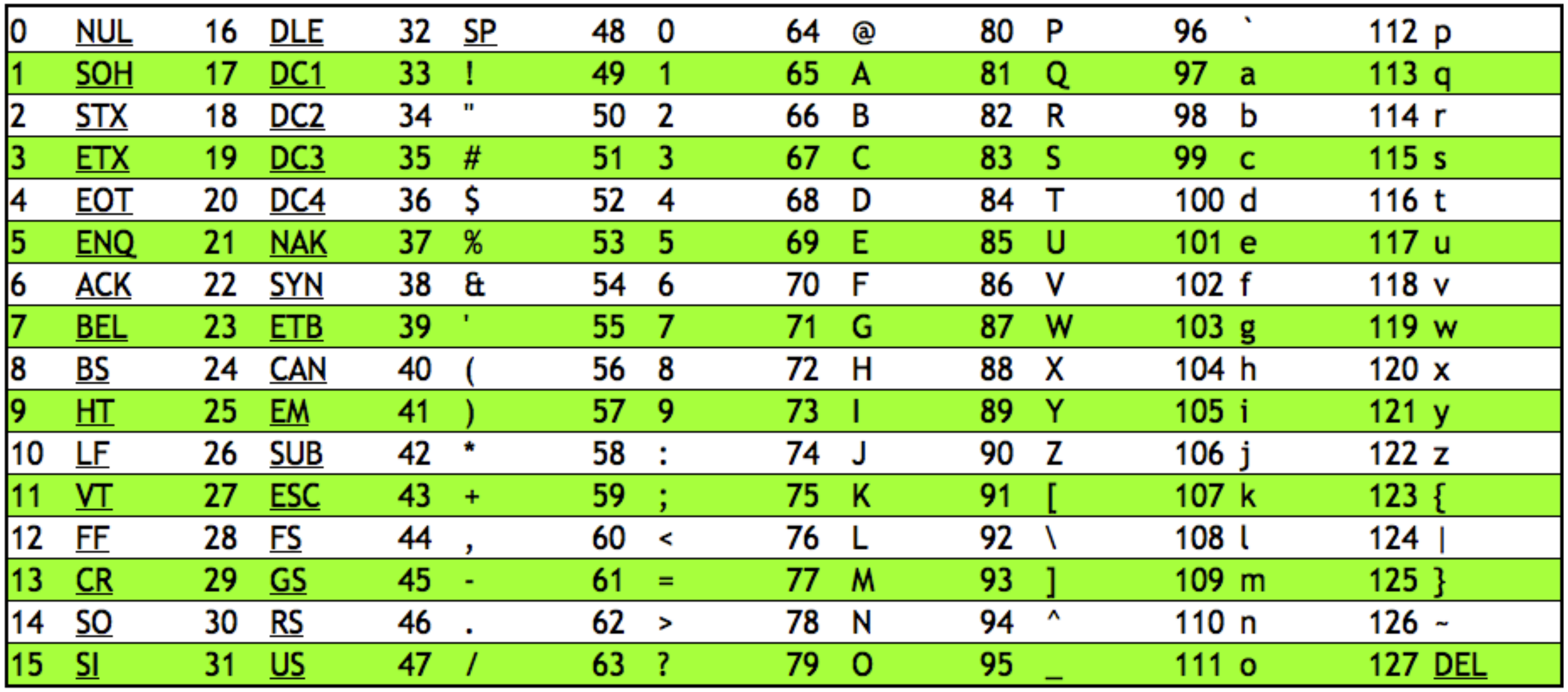
  - Subtract 40 from the the total hours to obtain the overtime hours
  - Multiply overtime hours by 1.5 times the rate of pay
  - Add overtime pay to base pay
- Output: Total Pay

String Comparison

String Comparison

- So far we have been writing Boolean expressions that evaluate based on numeric data
  - Example: x > 5; y < 10; z == 100
- We can also construct Boolean expressions that can test relationships between strings
- When we compare strings we are essentially reducing them to their zeros and ones and comparing them numerically

Standard ASCII Table



0	NUL	16	DLE	32	SP	48	0	64	@	80	P	96	`	112	p
1	SOH	17	DC1	33	!	49	1	65	A	81	Q	97	a	113	q
2	STX	18	DC2	34	"	50	2	66	B	82	R	98	b	114	r
3	ETX	19	DC3	35	#	51	3	67	C	83	S	99	c	115	s
4	EOT	20	DC4	36	$	52	4	68	D	84	T	100	d	116	t
5	ENQ	21	NAK	37	%	53	5	69	E	85	U	101	e	117	u
6	ACK	22	SYN	38	&	54	6	70	F	86	V	102	f	118	v
7	BEL	23	ETB	39	'	55	7	71	G	87	W	103	g	119	w
8	BS	24	CAN	40	(	56	8	72	H	88	X	104	h	120	x
9	HT	25	EM	41	)	57	9	73	I	89	Y	105	i	121	y
10	LF	26	SUB	42	*	58	:	74	J	90	Z	106	j	122	z
11	VT	27	ESC	43	+	59	;	75	K	91	[	107	k	123	{
12	FF	28	FS	44	,	60	<	76	L	92	\	108	l	124	|
13	CR	29	GS	45	-	61	=	77	M	93	]	109	m	125	}
14	SO	30	RS	46	.	62	>	78	N	94	^	110	n	126	~
15	SI	31	US	47	/	63	?	79	O	95	_	111	o	127	DEL

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Boolean Operators for Strings

```
'dog' > 'cat'                # is 'dog' greater than 'cat' ?

'fish' < 'alligator'         # is 'fish' less than 'alligator' ?

'elephant' == 'tiger'        # are 'elephant' and 'tiger'
                             # equivalent?
'bat' != 'honey badger'
                             # are these strings different ?
'bat' > 'back'
                             # is 'bat' greater than 'back'
```

Programming Challenge: Password Protection

- Write a program that asks the user for a password
- Check to see if the password that was submitted is equal to the string ‘secret’
- If it is, print out a “welcome” message
- Otherwise, tell them to try again

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Basic string manipulation

- Python has a huge string manipulation library that allows you to interact with and modify strings. We are going to get more in depth with this package later in the semester.
- For now we will only be exploring two small functions in this package – lower() and upper()
- The lower() function converts the characters in a string to all lowercase, while the upper() function converts the characters in a string to all uppercase
- These functions are not built into the Python library directly, but exist inside the "str" module – as such they must be referred to using "dot syntax"
- Example:
  - `string_lc = str.lower('Harry Potter')  # string_lc = 'harry potter'`
  - `string_uc = str.upper('Harry Potter')  # string_uc = 'HARRY POTTER'`

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Programming Challenge: Case insensitive password

- Rewrite your password protection program to be case insensitive (i.e. the password "Secret" will also let you into your program)

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Programming Challenge: Alphabetize two strings

- Ask the user to type in two names
- Compare the names and print them out in alphabetical order

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String Length

- You can ask Python to count the number of characters contained in a string using the len() function
- len() returns an integer that represents the total length of a string
- Example:

```
myname = ‘harry’
print (len(myname))   # 5
```

Programming Challenge: Comparing the size of two strings

- Ask the user to input two names
- Sort the names in size order and print them out to the user

Nested Decision Structures

Nested Decision Structures

- Sometimes you need to ask "follow up" questions after you've evaluated the value of a Boolean expression
- Python allows you to "nest" decision structures inside one another, allowing you to evaluate additional conditions

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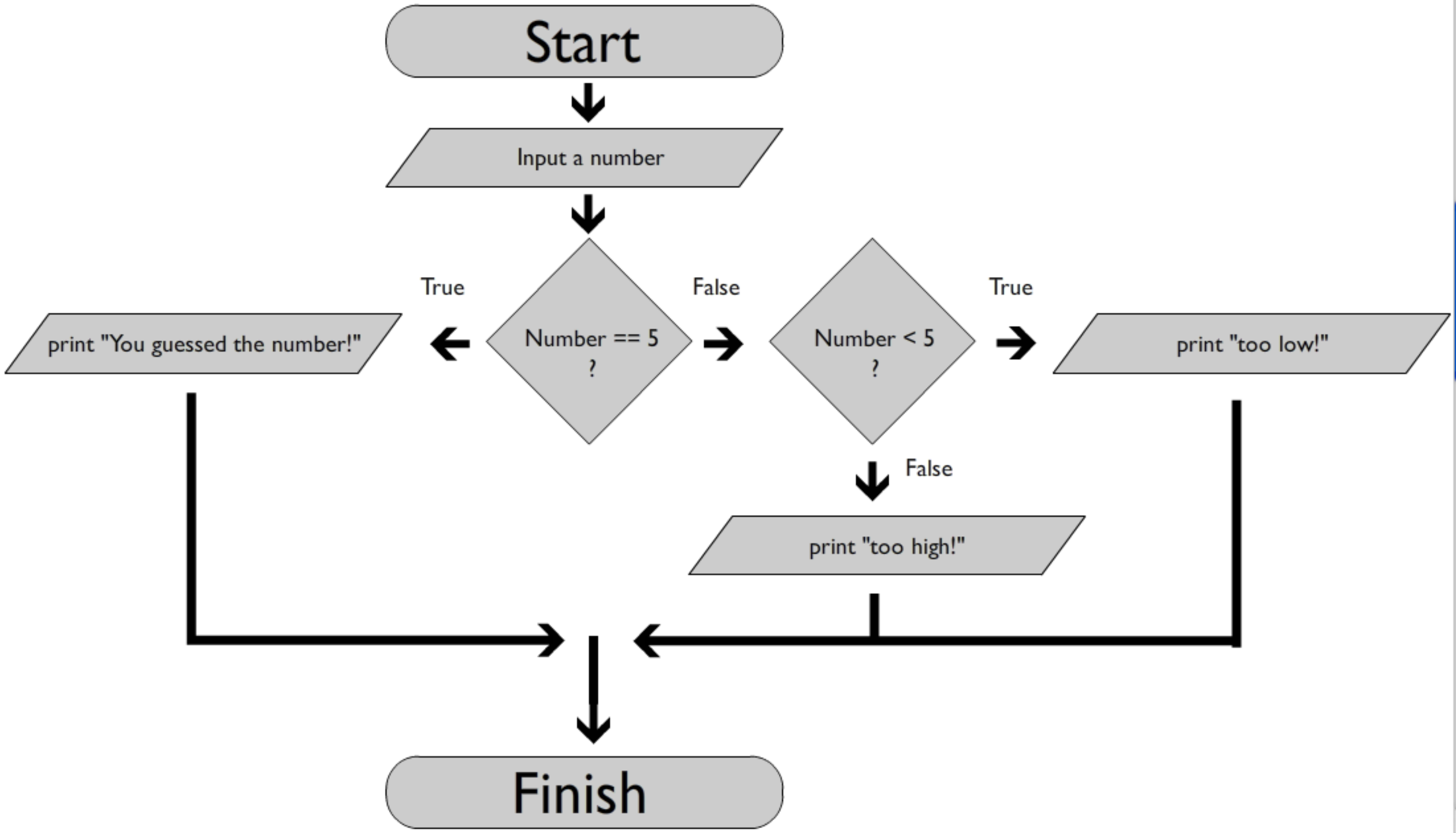
Guess the Number using Nested Decision Structures



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Guess the Number using Nested Decision Structures

```python
secretnumber = 5

usernumber = int(input('Guess a number '))

if usernumber == secretnumber:
    print ("you guessed it!")
else:
    if usernumber < secretnumber:
        print ("your number is too low")
    else:
        print ("your number is too high")
```

Nested Decision Structures

- Indentation is key – Python will use the indentation level of a structure to determine its relationship to any previous statements

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Programming Challenge: Freezing / Boiling / OK Guppies

- Guppies are hardy fish, but they can't live in all water temperatures.
- The acceptable range for guppies is between 72 and 86 degrees Fahrenheit.
- Write a program that asks the user for a temperature. Then display one of three messages based on the information provided:
  - You're going to freeze your guppy!
  - You're going to boil your guppy!
  - Your guppy is going to be fine!

+

Programming Challenge

- Write a program that asks the user to enter in a number greater than or equal to zero and less than or equal to 100. If they do not you should alert them and end the program.
- Next, determine the letter grade associated with the number. For example, and A is any grade between 90 and 100. Report the letter grade to the user.

Programming Challenge: Loan Qualification

- You're working for a small bank that wants to write a program to allow its customers to pre-qualify themselves for a personal loan
- Rules for qualification are as follows:
  - Borrower must make more than $50,000 per year and be at his or her job for at least 2 years
  - The 2 year job requirement can be waived, however, for borrowers making more than $100,000 per year
- Write a program to ask the user for their yearly salary as well as the # of years they have been at their current company. Use the rules above to output the string 'You qualify' or 'You do not qualify'

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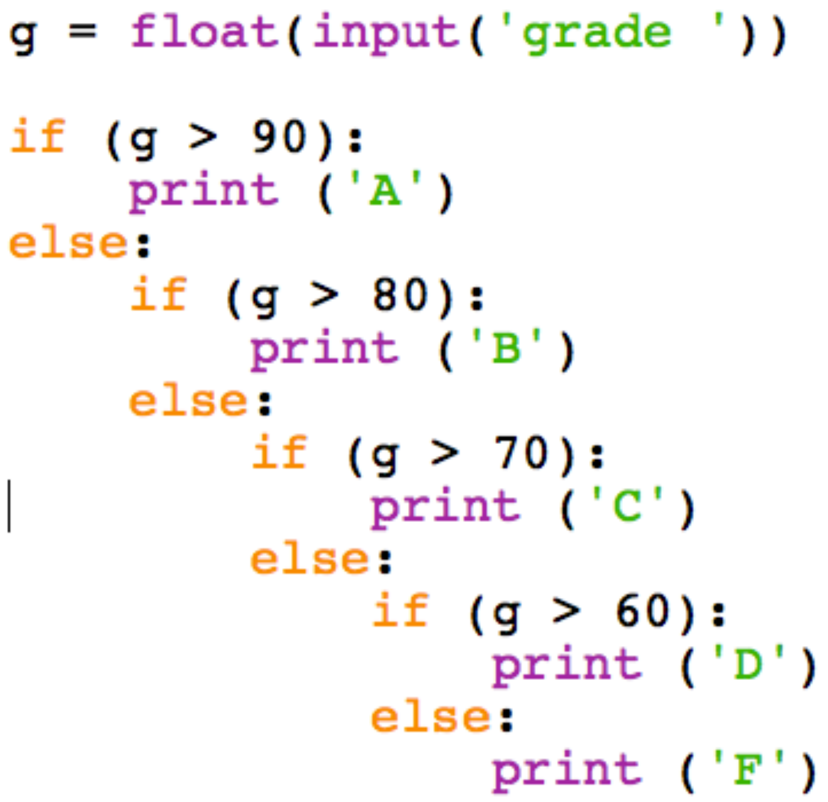
IF-ELIF-ELSE Structure

Testing a series of conditions

- Testing a series of conditions using an IF-ELSE structure can result in a large amount of indentations
- Sometimes this can cause your code to become difficult to read
- Example: Grade determination program
  - Input: ask the user for a numeric grade (i.e. 95)
  - Process: convert the grade to its letter format (A through F)
  - Output: print the letter grade

Grade Determination Program



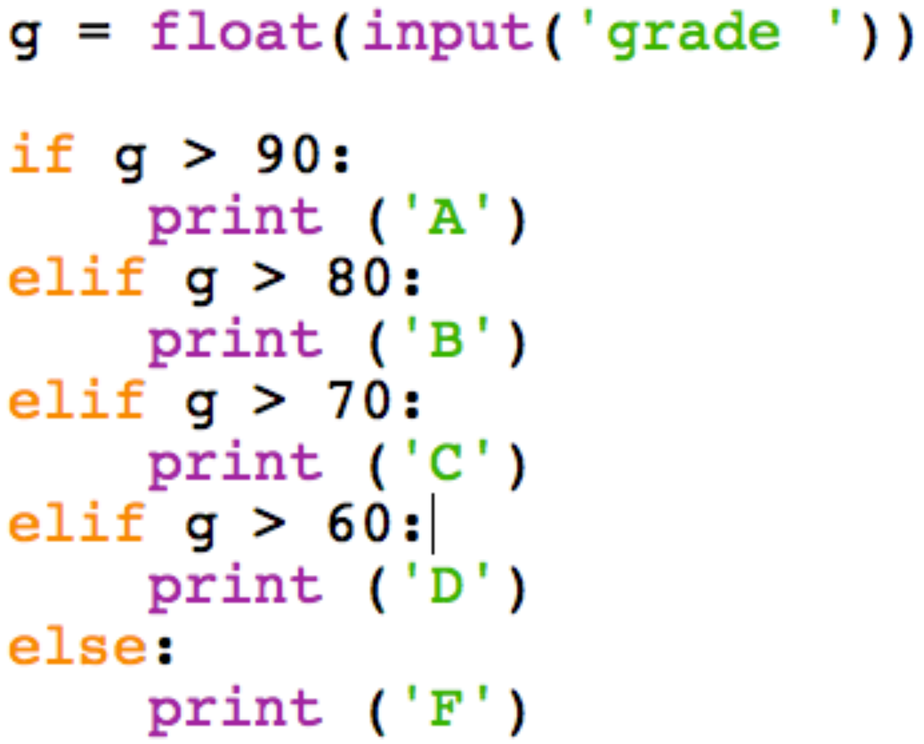
```
g = float(input('grade '))

if (g > 90):
    print ('A')
else:
    if (g > 80):
        print ('B')
    else:
        if (g > 70):
            print ('C')
        else:
            if (g > 60):
                print ('D')
            else:
                print ('F')
```

+

IF-ELIF-ELSE

- You can simplify complex IF statements by using the ELIF structure
- ELIF is an optional structure that can be placed between your IF and ELSE statements
- It allows you to evaluate additional conditions at the same level as the original IF statement

+ IF-ELIF-ELSE



```
g = float(input('grade '))

if g > 90:
    print ('A')
elif g > 80:
    print ('B')
elif g > 70:
    print ('C')
elif g > 60:
    print ('D')
else:
    print ('F')
```

+
IF-ELIF-ELSE

- Conditions are tested in the order in which they are written. Once a condition evaluates to True all future conditions are skipped
- An ELSE statement at the end of a decision structure is considered the "catch all" statement – if all conditions above end up failing then the statements inside the ELSE block will execute
- However, using an ELSE statement at the end of your decision structure is optional.
- There is no logical need for an IF-ELIF-ELSE statement. You can always write a program without it by using a standard IF-ELSE block. The advantage of an IF-ELIF-ELSE statement is that your code may end up being be more readable / understandable.

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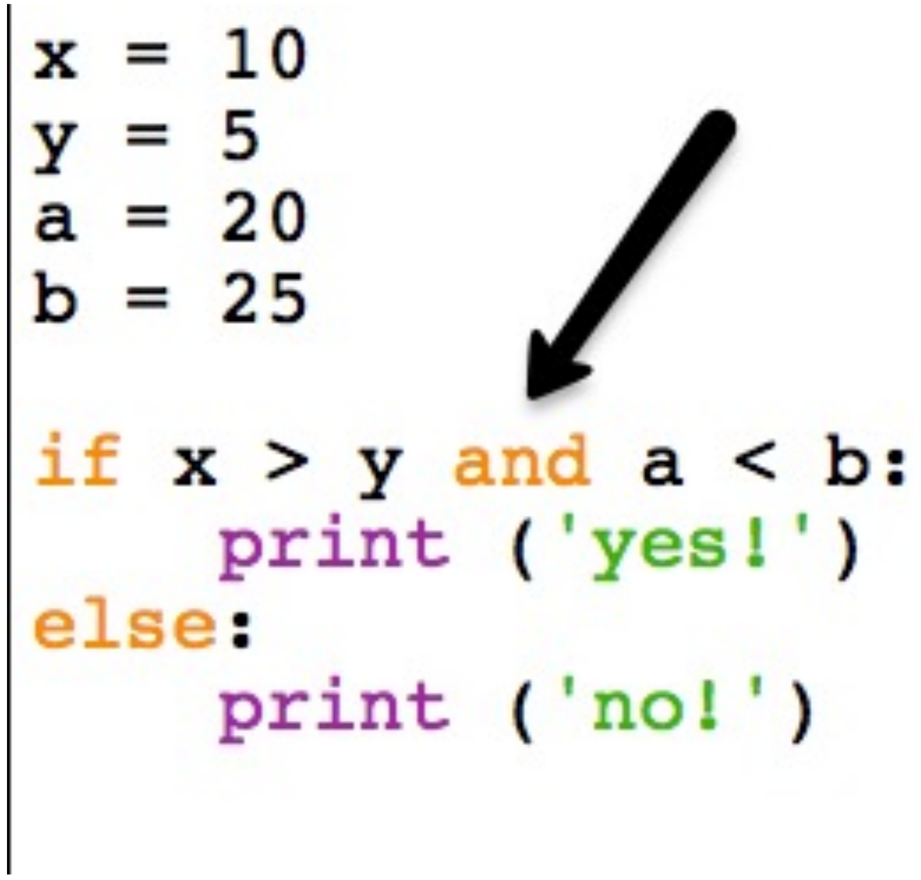
Logical Operators

Logical Operators

- All programming languages provide a set of “logical operators”
- These operators can be used to create complex Boolean expressions that evaluate more than one condition at the same time

+ Logical Operators



```
x = 10
y = 5
a = 20
b = 25

if x > y and a < b:
    print ('yes!')
else:
    print ('no!')
```

Logical Operators

- Logical operators are used to combine Boolean expressions into a composite Boolean expression
- There are three main logical operators that we use regularly in programming
  - and
  - or
  - not

+
The "and" operator

- "and" can be used to combine two Boolean expressions
- The resulting Boolean expression will evaluate to be True if the two Boolean expressions it is connecting both evaluate to be True

```
True  and True  => True

True  and False => False

False and True  => False

False and False => False
```

+

Let’s evaluate!

```
a = 5

b = 10

print (a > b and a > 1)

print (a > 1 and b > a)

print (a == 5 and b < 100)

print (a > 1 and b < 1 and b > a)

print (a > 1 and b > 1 and b > a)
```

+
“and” Example

Loan Qualifier

```
salary = float(input('How much do you make? '))
years  = float(input('How long have you been at your job? '))

if salary >= 50000 and years >= 2:
    print ('You qualify for a loan!')

else:
    print ('You do not qualify for a loan')
```

+
The "or" operator

- "or" can also be used to combine two Boolean expressions
- The resulting Boolean expression will evaluate to be True if EITHER of Boolean expressions it is connecting evaluates to be True

```
True  or True  => True

True  or False => True

False or True  => True

False or False => False
```

+
Let’s evaluate!

```
a = 5

b = 10

print (a > b or a > 1)

print (a > 1 or b > a)

print (a == 5 or b < 100)

print (a > 1 or b < 1 or b > a)

print (a > 1 or b > 1 or b > a)
```

+

“or” Example

Guppy Temperature

```
temp = float(input('What is the temperature of your fish tank? '))

if temp < 72 or temp > 86:
    print ("The temperature is too extreme!")
```

The “not” operator

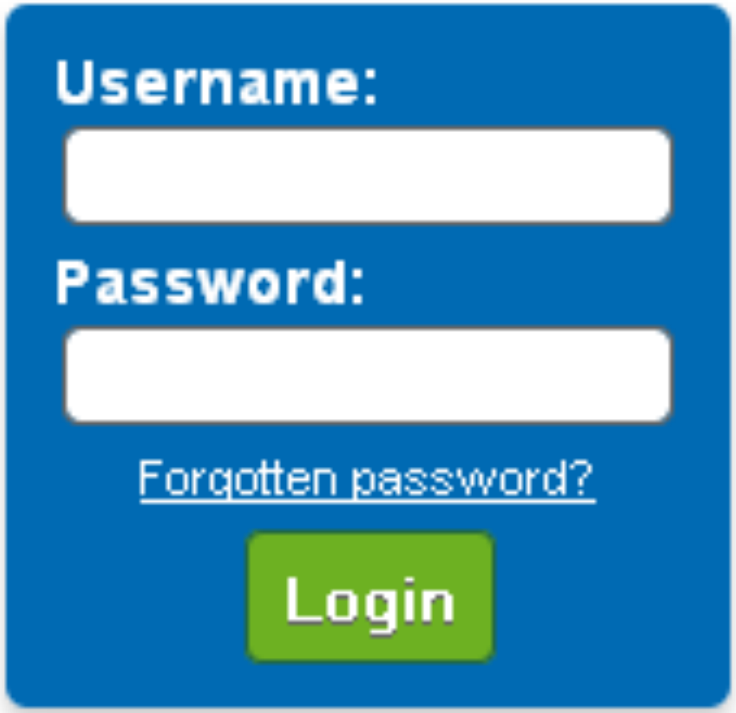
- The “not” operator is a unary operator that reverses the logical value of its argument
- This means that it will “flip” a True value into a False value, and vice versa

+
“not” example

```
username = input('username? ')


if not (username == 'Harry'):

    print("invalid input!")

else:

    print("Welcome, Harry!")
```

+
Programming Challenge: Username and Password

- Write a program that asks a user for a username and a password
- Check to see if BOTH the username and password are correct
- If so, provide a Welcome message to the user
- If not, provide a Login Failure message to the user

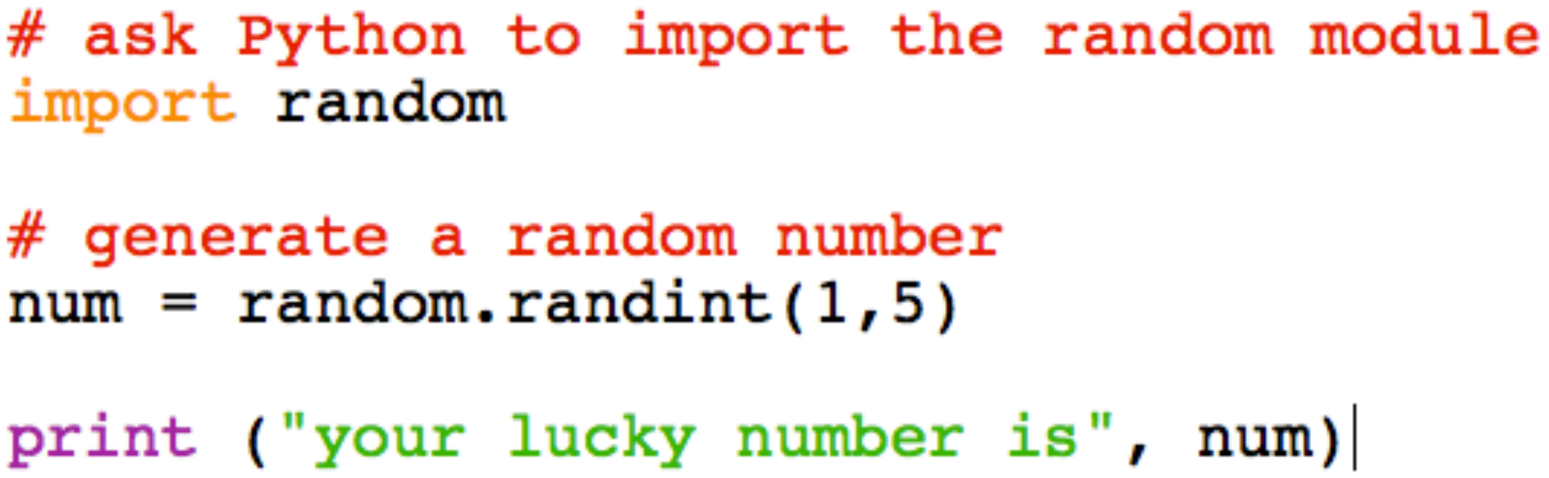


Generating Random Numbers

Generating a random integer

- Sometimes you need your program to generate information that isn't available when you write your program
- One way to solve this problem is to ask your programming language to select a "random number" – from there you can use this number to construct a somewhat random set of running conditions
- You can generate a random number by using the randint() function. This function takes two parameters (a starting integer and an ending integer) and returns one value (a random integer in this range)
- In order to use the randint() function you must first "import" the "random" module so that Python can access the necessary code library.

Random Integer Example



```
# ask Python to import the random module
import random

# generate a random number
num = random.randint(1,5)

print ("your lucky number is", num)
```

+

Programming Challenge: Rock, Paper, Scissors

- Write a program to ask the user to select one of three options - Rock (r), Paper (p) or Scissors (s)
- Use the random.randint() function to select an option for the computer
- Determine the winner and print the result.
  - Rock beats Scissor
  - Scissor beats Paper
  - Paper beats Rock

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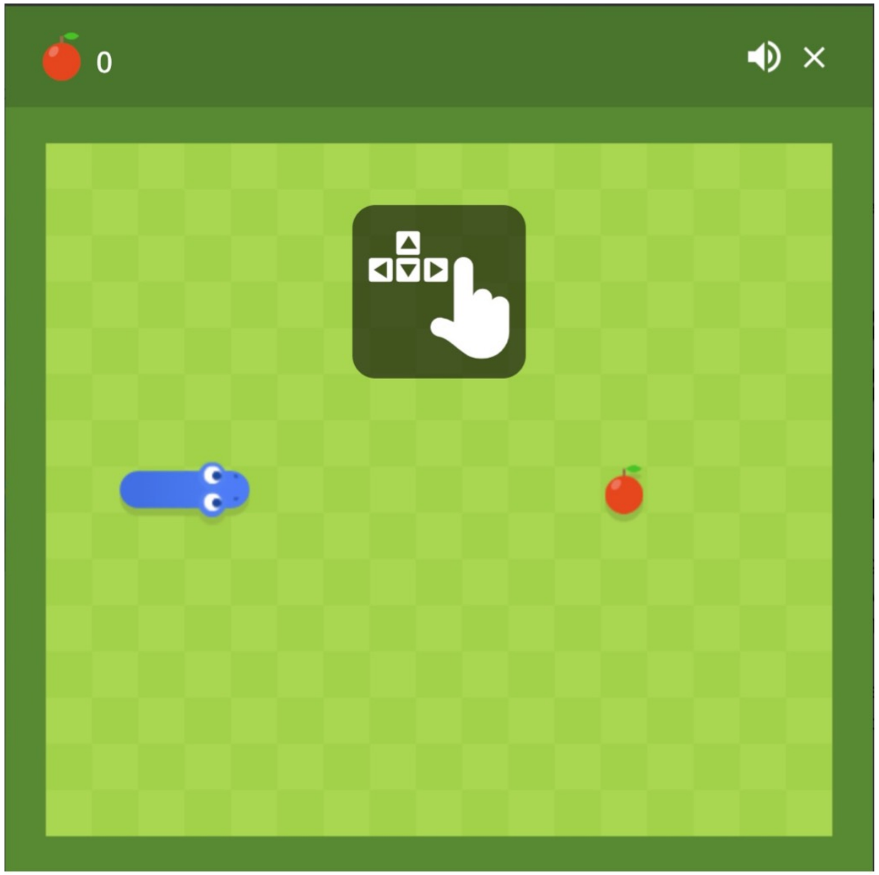
Random Numbers in the Wild

Game Development



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Random Numbers in the Wild

NFTs and Generative Art