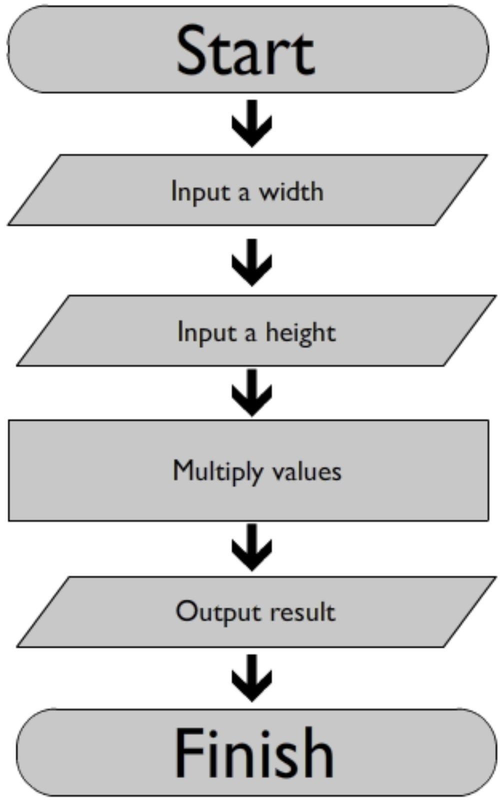
DECISION STRUCTURES & BOOLEAN LOGIC

Sequence Structures

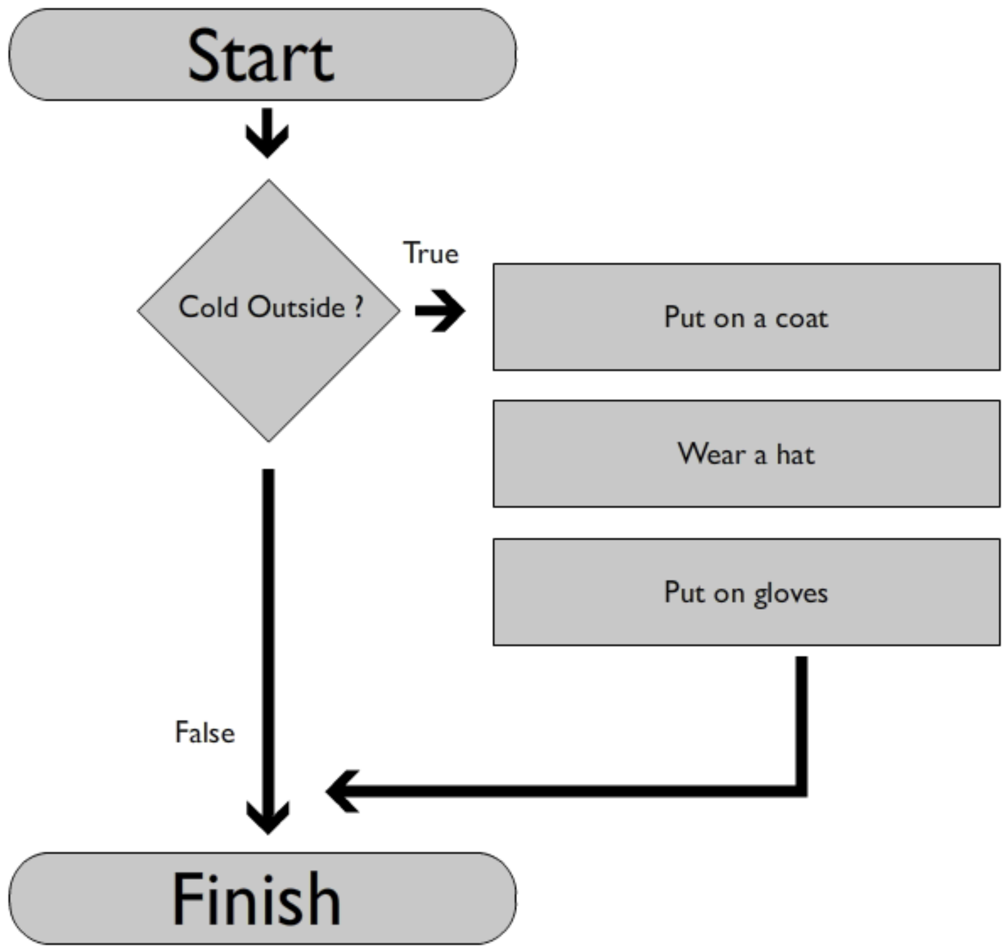
- What we have been programming so far is known as a "sequence structure"
- Sequence structures are sets of statements that execute in the order in which they appear
- Unfortunately not all programs can be written this way, as there are certain times when we need to deviate from a linear structure and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



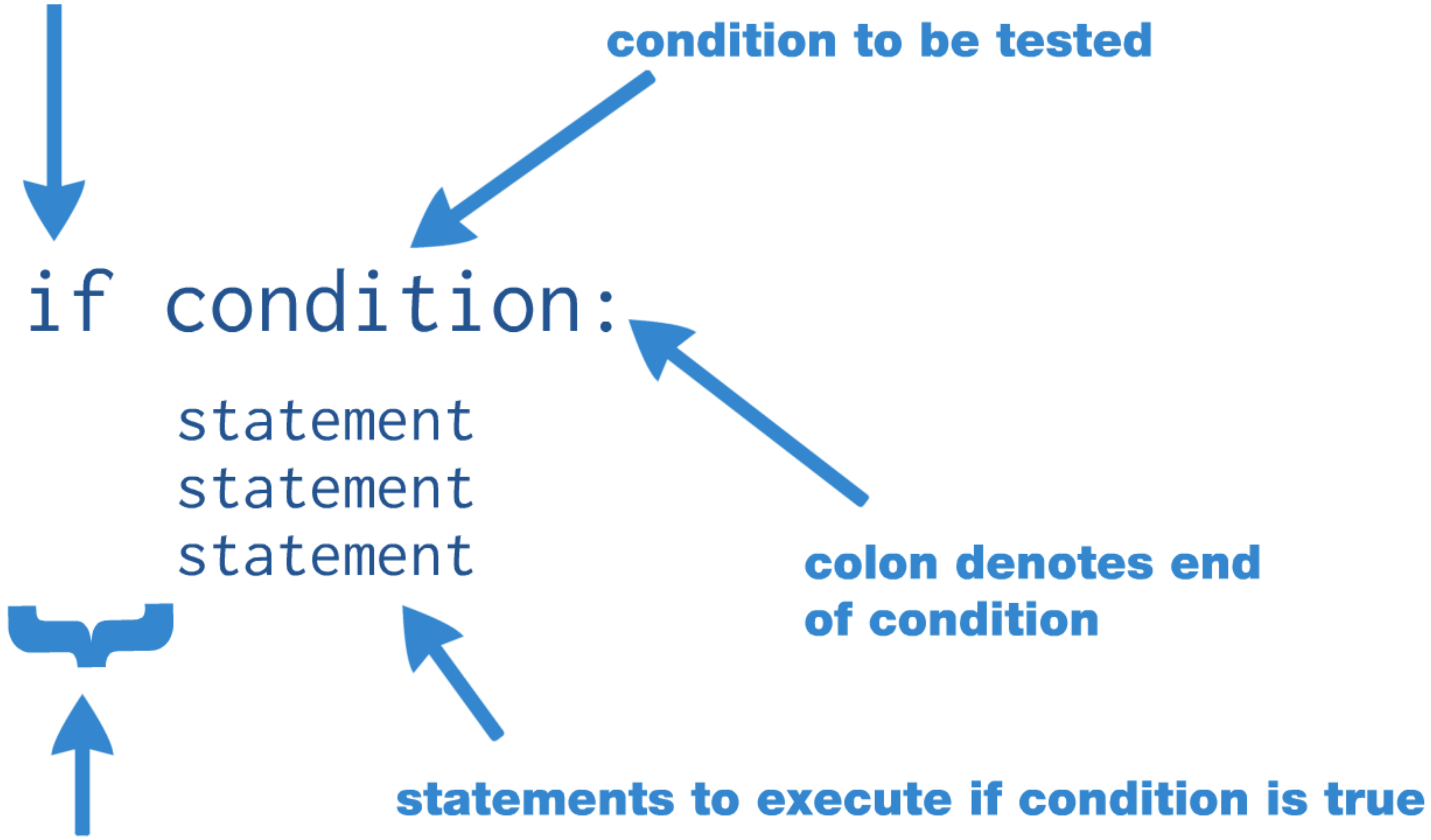
The Selection Statement

- 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



Selection Statements in Python

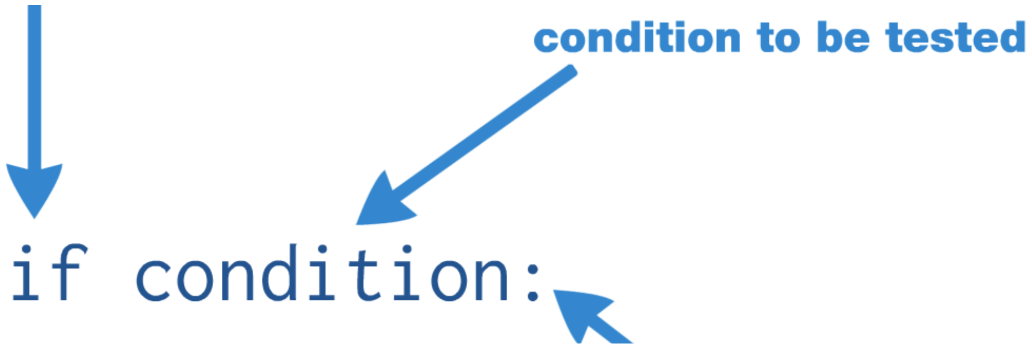


```
if condition:
      statement
      statement
      statement
```

condition to be tested
colon denotes end of condition
statements to execute if condition is true

Boolean Expressions

Writing a condition



```
if condition:
```

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

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

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”

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

Example: Conditional Program Execution

- There are several ways of running Python programs.
  - Some modules are designed to be run directly. These are referred to as **programs or scripts**.
  - Others are made to be imported and used by other programs. These are referred to as **libraries**.
  - Sometimes we want to create a **hybrid** that can be used both as a stand-alone program and as a library.

Example: Conditional Program Execution

- When we want to start a program once it's loaded, we include the line `main()`
  at the bottom of the code.

- Since Python evaluates the lines of the program during the import process, our current programs also run when they are imported into an interactive Python session or into another Python program.

Example: Conditional Program Execution

- Generally, when we **import** a module, we don't want it to execute!

- In a program that can be either run stand-alone or loaded as a library, the call to **`main`** at the bottom should be made conditional, e.g.

```
if <condition>:
   main()
```

Example: Conditional Program Execution

- Whenever a module is imported, Python creates a special variable in the module called `__name__` to be the name of the imported module.

- Example:

```
>>> import math
>>> math.__name__
'math'
```

Example: Conditional Program Execution

- When imported, the `__name__` variable inside the math module is assigned the string `‘math’`.

- When Python code is run directly and *not* imported, the value of `__name__` is `'__main__'`. E.g.:

```
>>> __name__
'__main__'
```

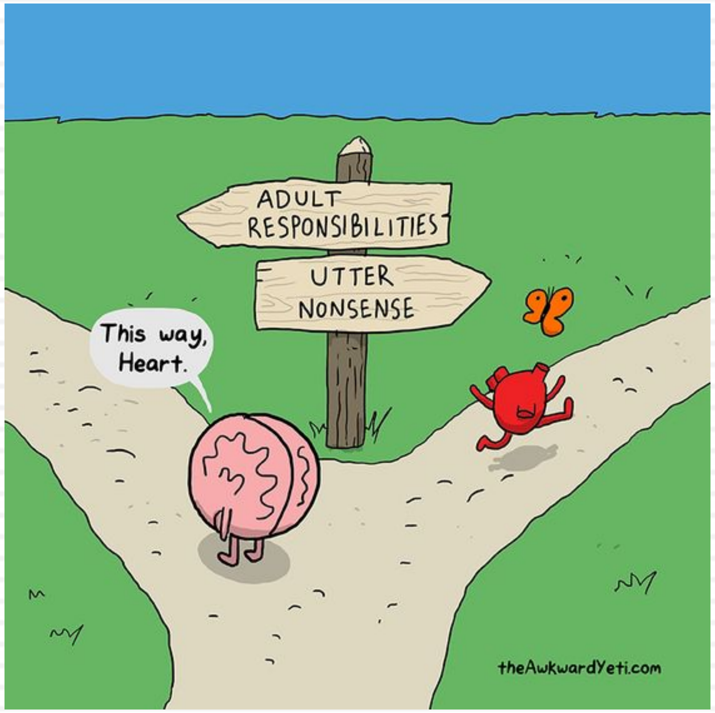
Example: Conditional Program Execution

- To recap: if a module is imported, the code in the module will see a variable called `__name__` whose value is the name of the module.
- When a file is run directly, the code will see the value `‘__main__’`.
- We can change the final lines of our programs to:

```
if __name__ == '__main__':
    main()
```

- Virtually every Python module ends this way!

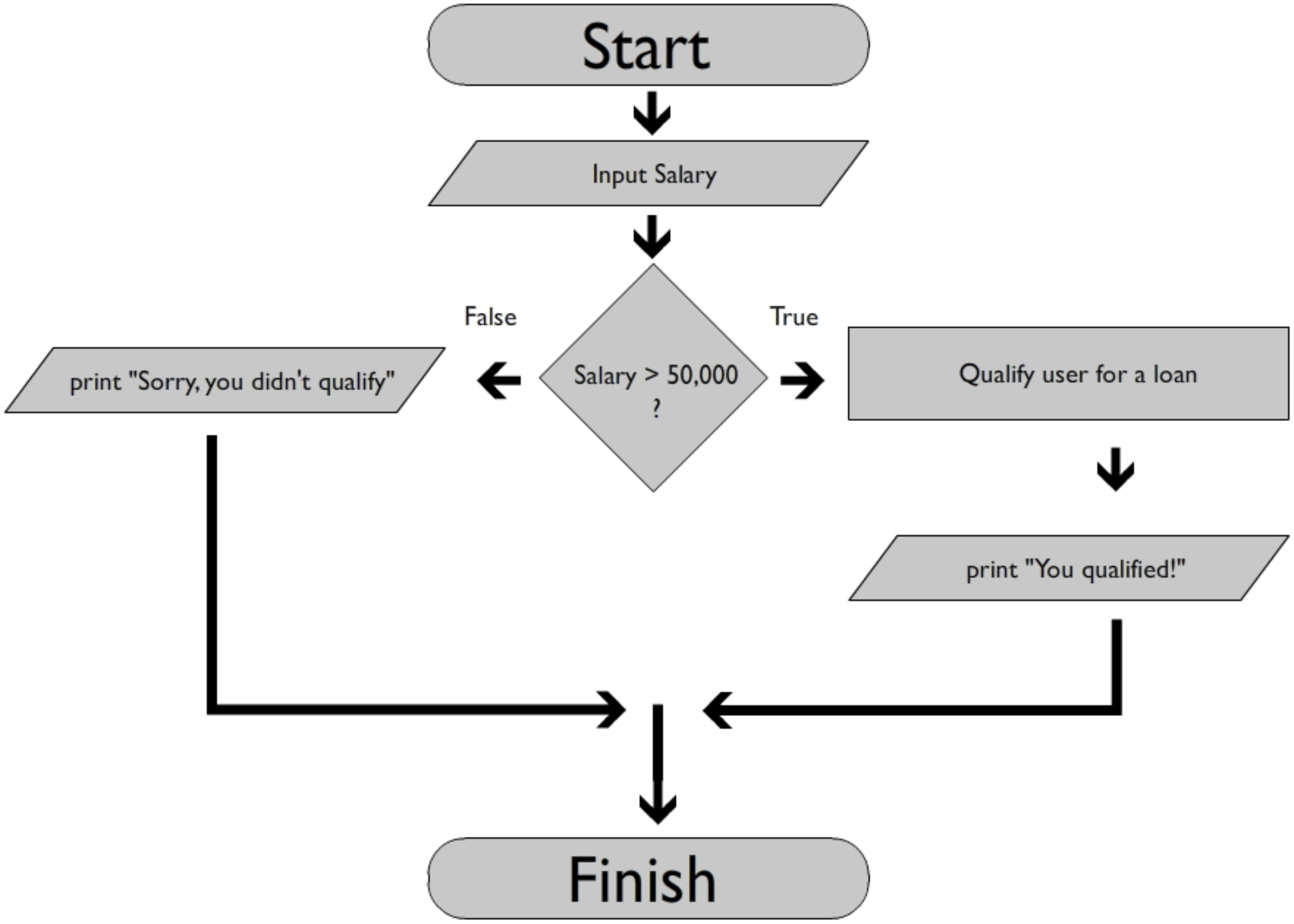
The IF – ELSE structure



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

The IF-ELSE structure



The IF-ELSE structure

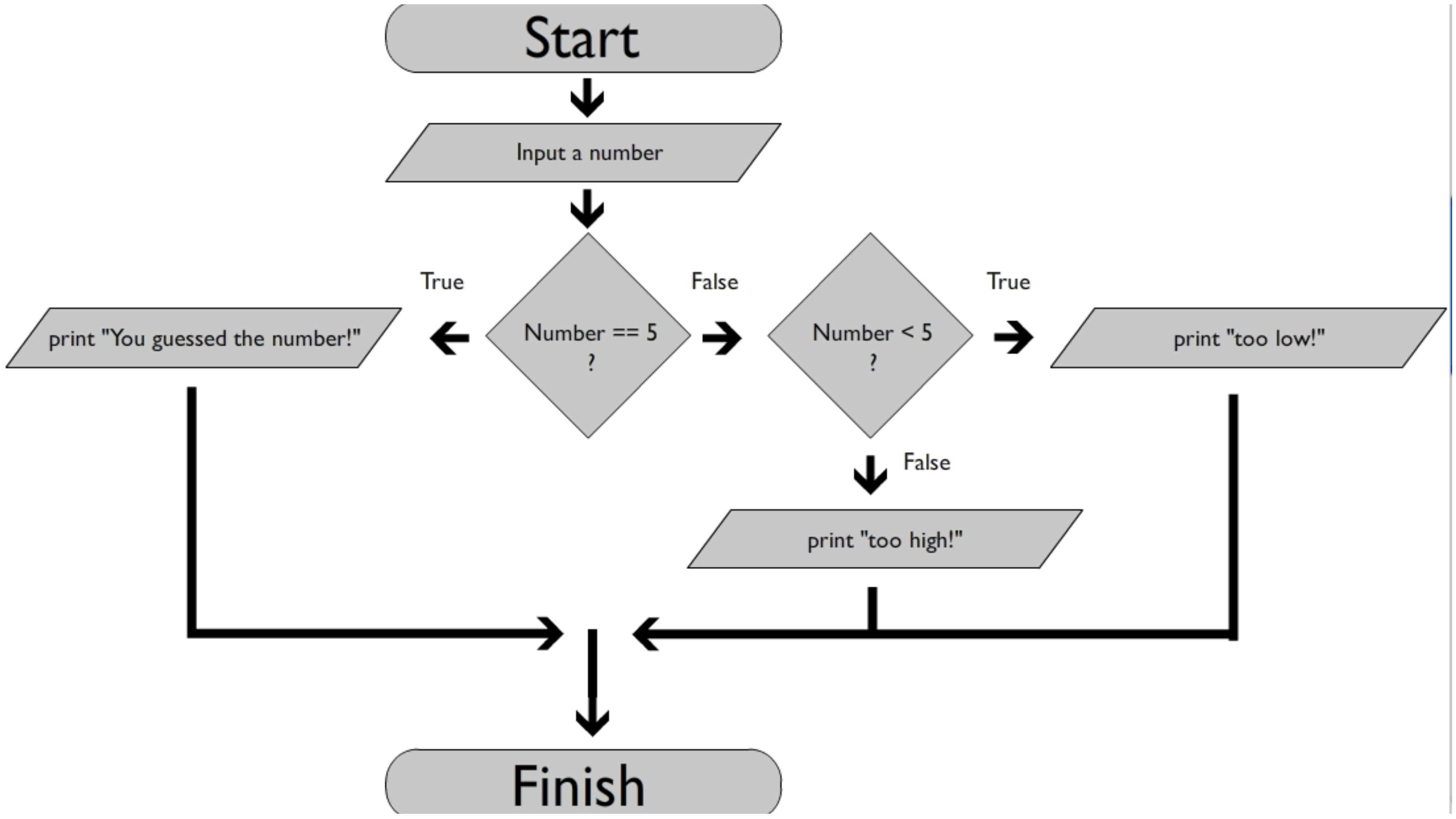
```
if temperature < 32:
  print (“it’s freezing outside!”)
else:
  print (“it’s not so bad outside
  …”)
```

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

Guess the Number using Nested Decision Structures



Nested Decision Structures

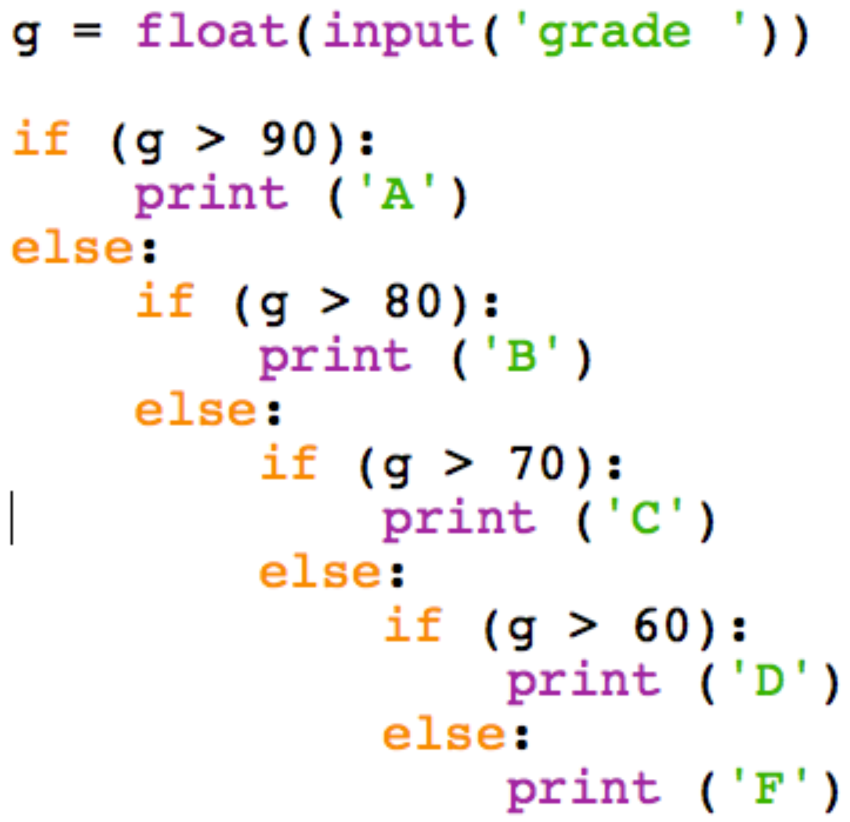
- Indentation is key – Python will use the indentation level of a structure to determine its relationship to any previous statements

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

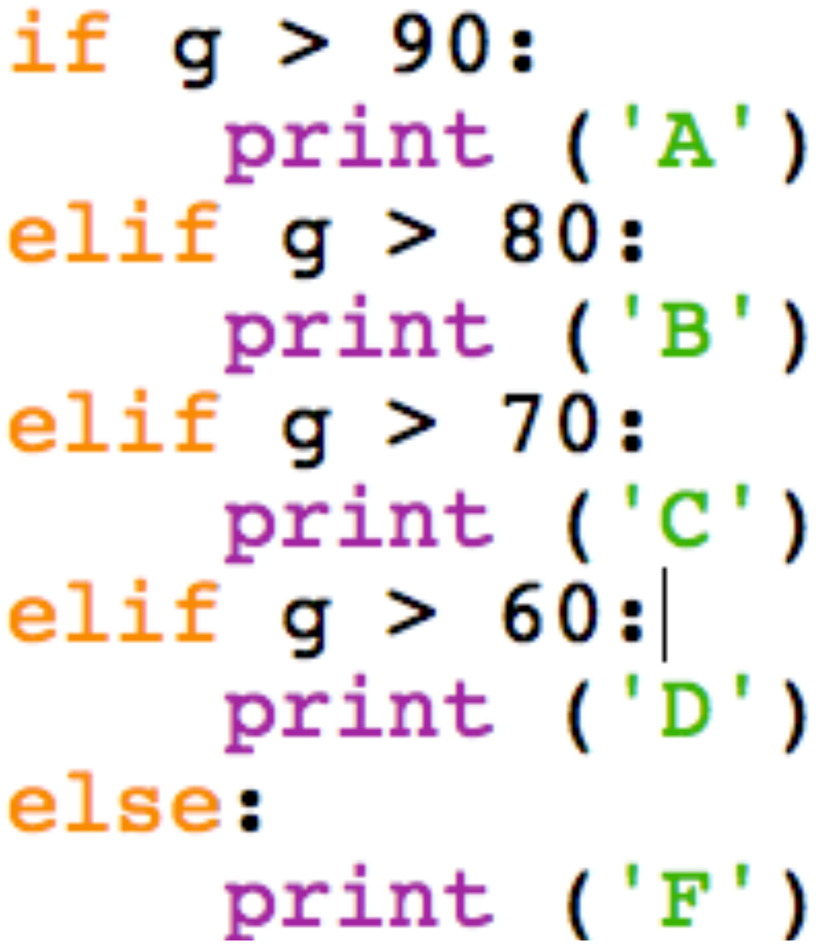


```python
g = float(input('grade '))

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



```
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

- Some notes about using ELIFs:
  - 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.

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

Boolean Operators for Strings

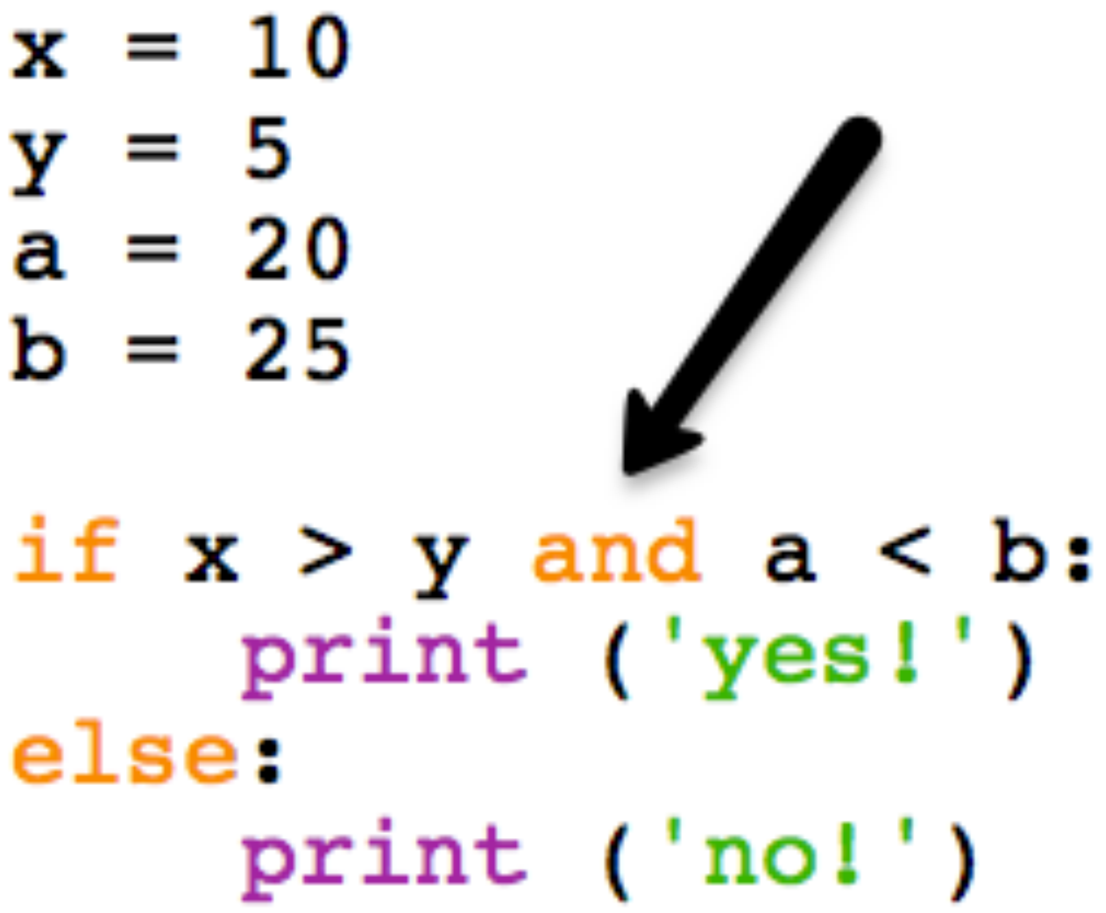
```
'dog' > 'cat'          # is 'dog' greater than
                         'cat' ?

'fish' <               # is 'fish' less than
  'alligator'            'alligator' ?
'elephant' ==          # are 'elephant' and
  'tiger'                'tiger'
                       # equivalent?

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

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
```

“and” Example

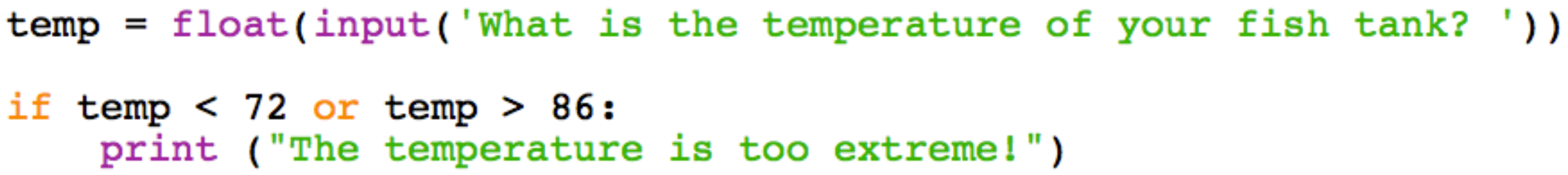
```
salary = float(input('How much do you make? '))
years  = float(input('How long have you been at your job? '))

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
```

“or” Example



```
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

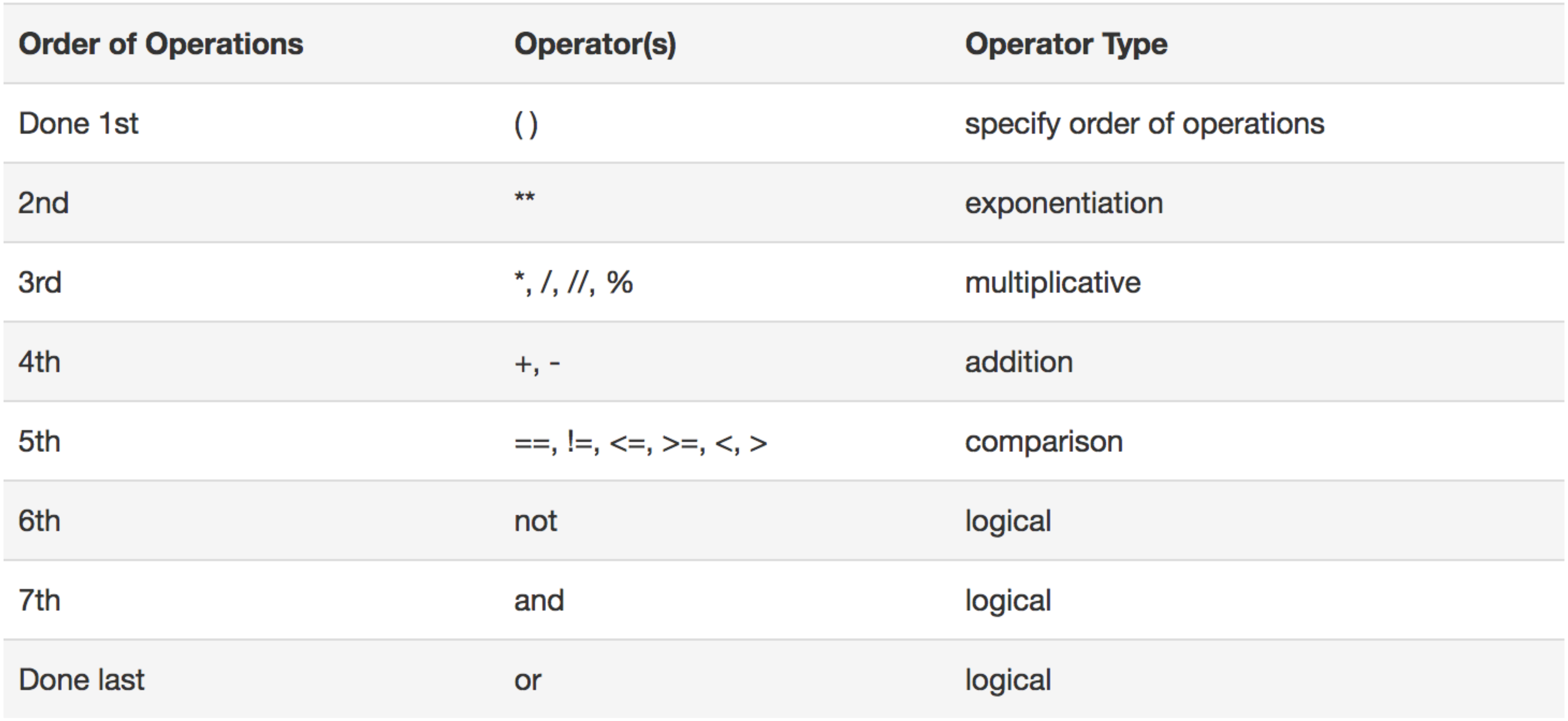
- The “not” operator is a unary operator that reverses the logical value of its argument
- This means that it will “flip” a True value into a False value, and vice versa

“not” example

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

if not (username == 'Harry'):
    print("invalid input!")
else:
    print("Welcome, Harry!")
```

“not” vs. !=

- Partially readability, but mostly this:



Order of Operations	Operator(s)	Operator Type
Done 1st	( )	specify order of operations
2nd	**	exponentiation
3rd	*, /, //, %	multiplicative
4th	+, -	addition
5th	==, !=, <=, >=, <, >	comparison
6th	not	logical
7th	and	logical
Done last	or	logical

Let’s write some programs!

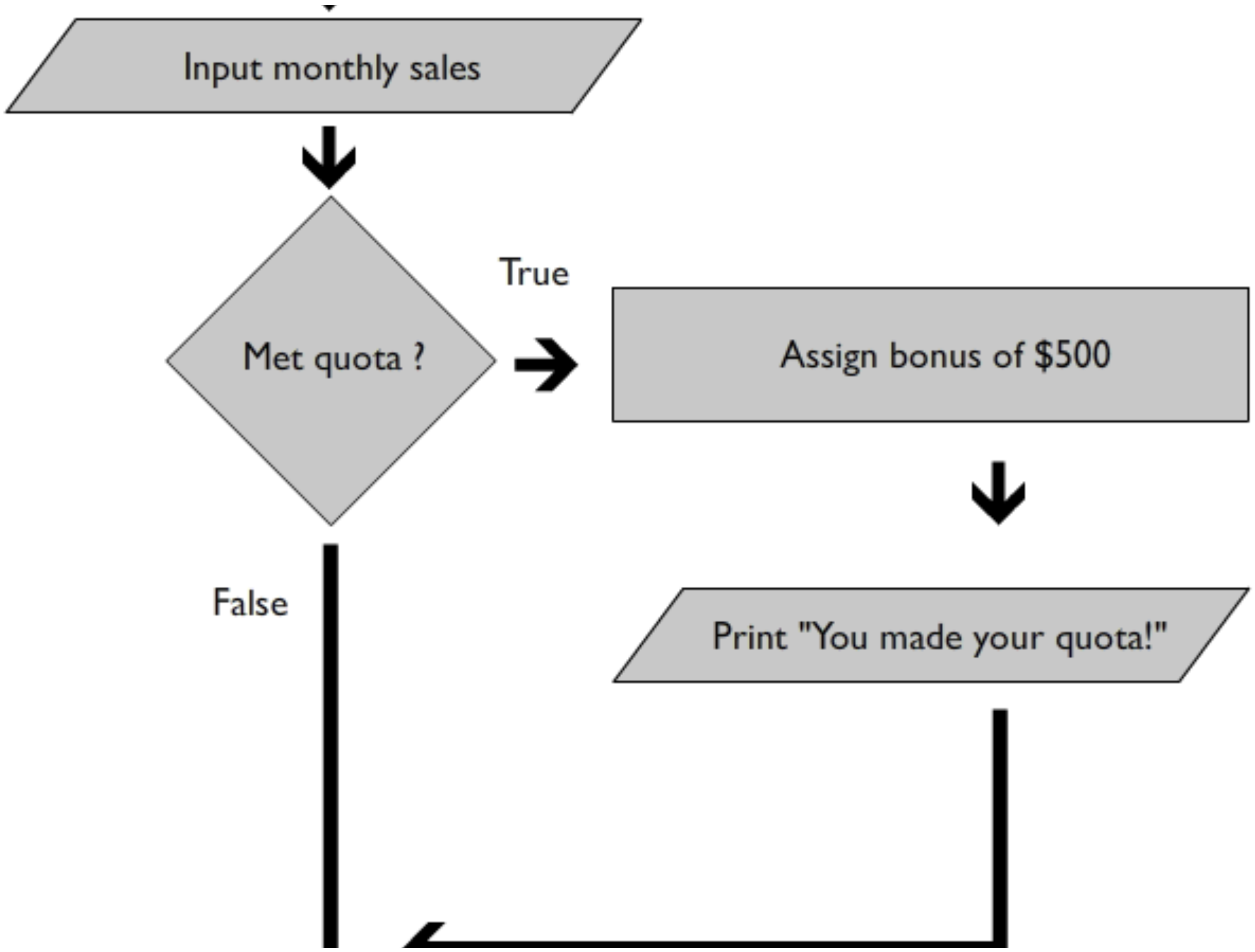
Programming Challenge: Number Guessing Game (part 1)

- 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)

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

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
- 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

Programming Challenge: Alphabetize two strings

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

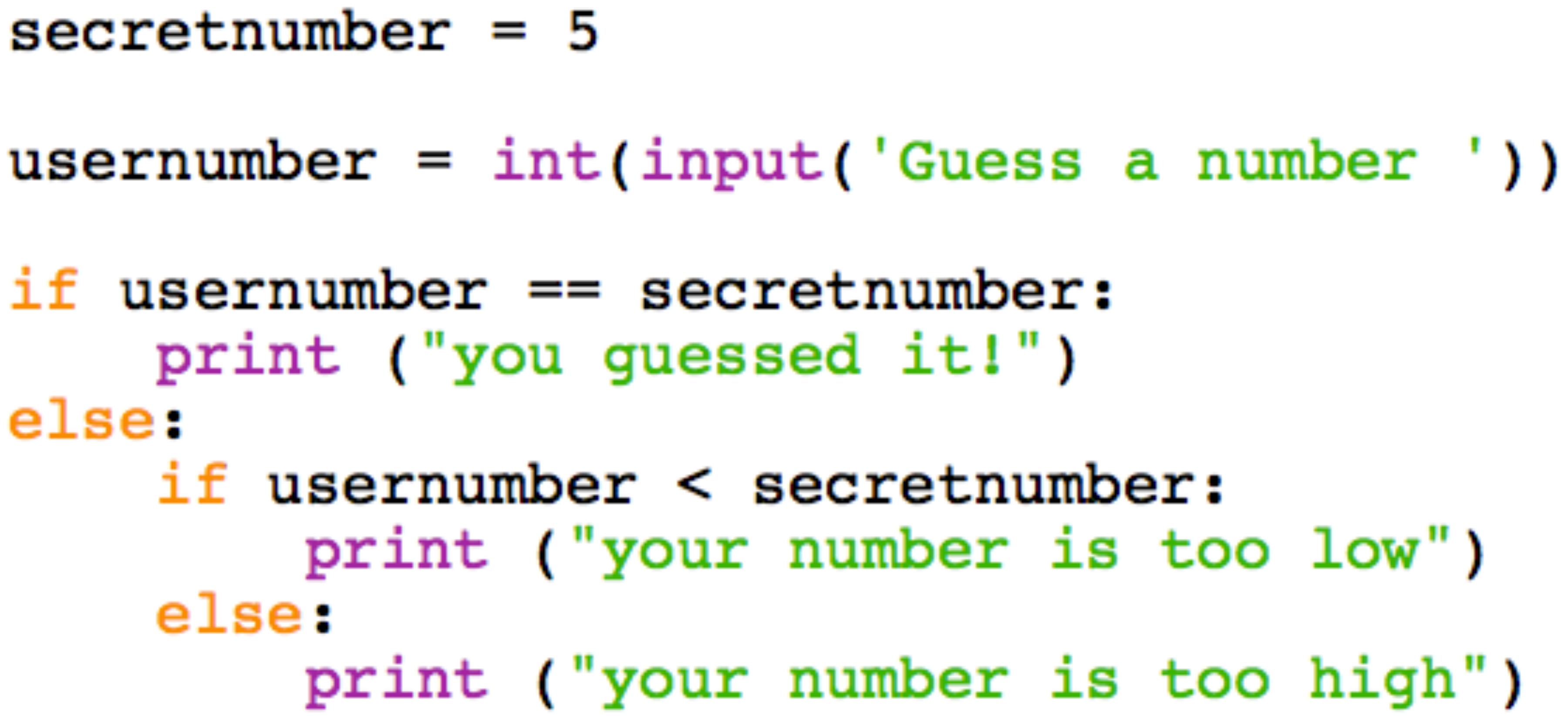
Programming Challenge: Comparing the size of two strings

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

Programming Challenge

- Re-write the "guess the number" game using a nested decision structure.
- If the user guesses the number they win. If they don't you should tell them to guess higher or lower next time depending on their answer.

Guess the Number using Nested Decision Structures



```
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")
```

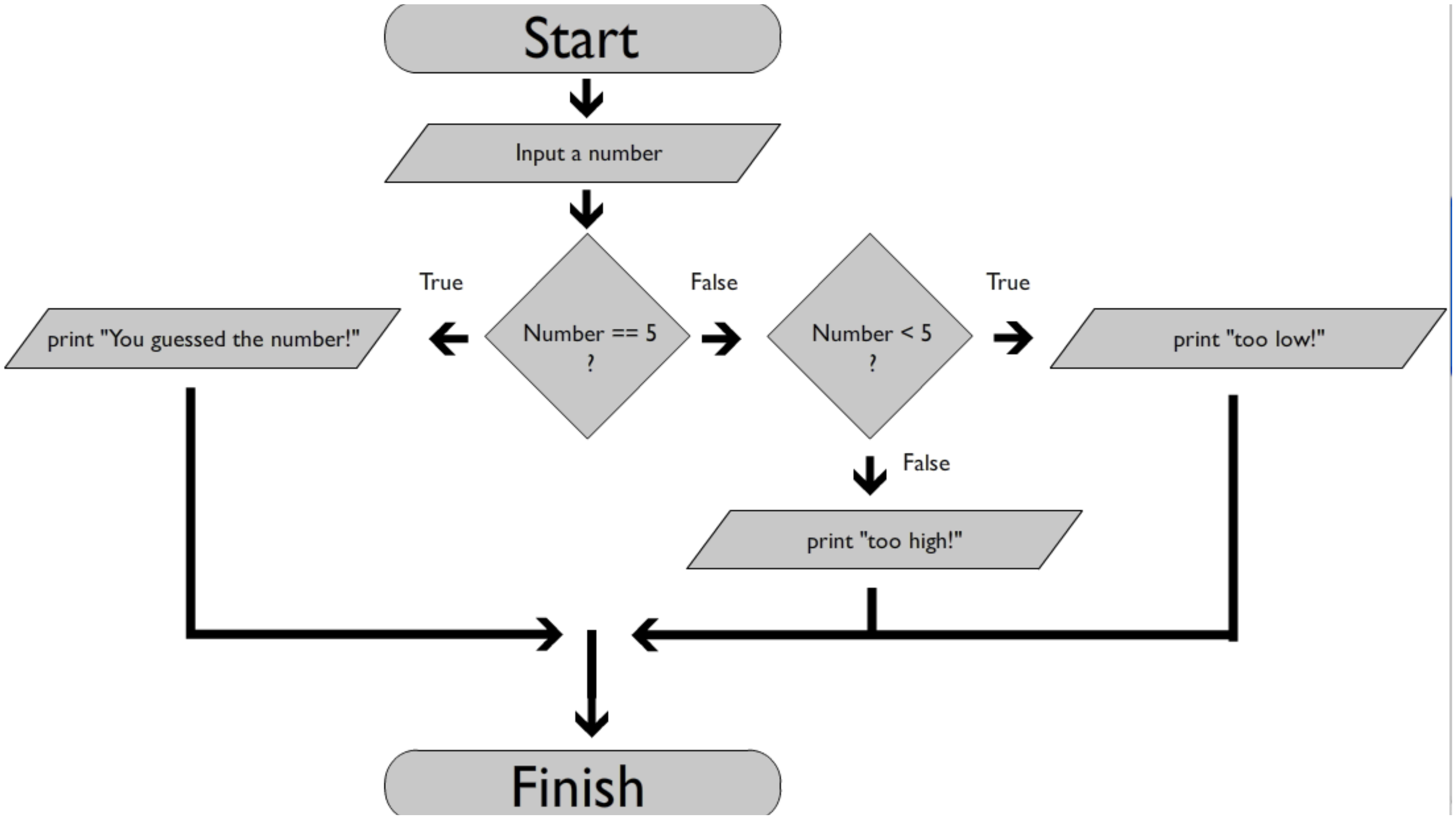
Programming Challenge

- 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'

Guess the Number using Nested Decision Structures

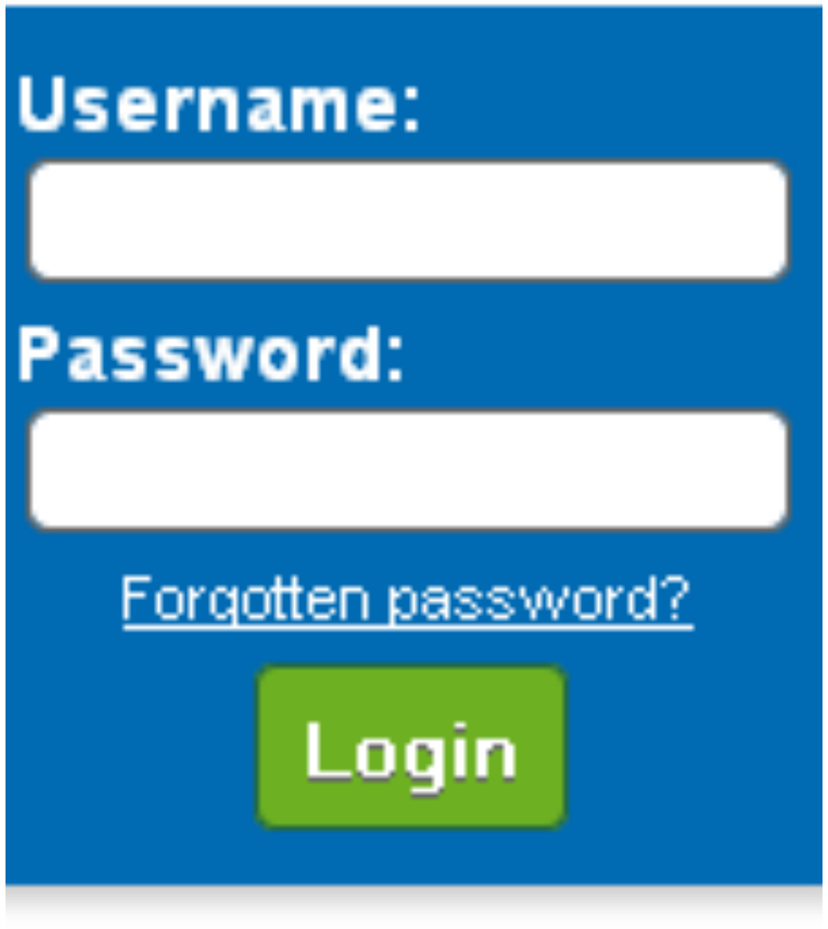


Guess the Number using Nested Decision Structures

```
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")
```

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


Username:
Password:
Forgotten password?
Login