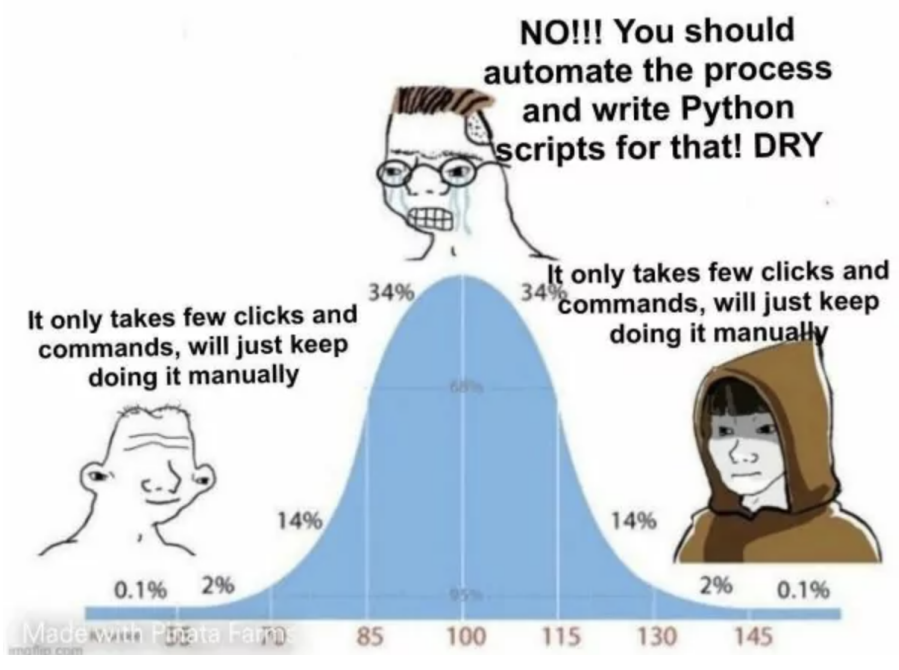
Discussion 10

DSC 20, Fall 2023

Final Exam Review 

Meme of the week



Logistics

- Final Exam takes place Friday, December 15th
- 8am - 11am
- Location: refer to EDstem whenever its posted (CENTR 109/147)
- cheatsheet allowed (normal A4 double-sided)
- make sure to bring ID and pencils

Midterm 1 Content

- Basics
- Conditional Statements
- Doctests
- Loops
- List, tuple, set, Dictionaries
- List/Dict comp
- indexing/slicing
- files/text processing
- asserts

Basic Operations

+ - Numerical addition / concatenation operator

- - Numerical Subtraction operator

/ - Classic Division operator

// - Floor Division operator

***** - Numerical Multiplication / repetition operator

****** - Numerical Exponential operator

% - Numeric remainder operator

Basic Data Types

String - Data type for text

Int - Data type for whole numbers

Float - Data type for non-integers

Bool - True or False

note: **None** is technically its own type

Boolean Operators

Logical Operators (in order priority):

- **not** - reverses the outcome of the following expression
- **and** - all expressions compared with “and” must be True to evaluate True
- **or** - at least one expression compared with “or” must be True to evaluate True

Comparison Operators (generates booleans):

- **==** - equality check
- **!=** - inequality check
- **>, >=, <, <=** directional check

note: order of evaluation is overriden by parentheses (just like PEMDAS)

Checkpoint

What is the output of the following code?

In [ ]:
```
bool(-100)
```

Checkpoint Solution

In [3]:
```
bool(-100)
```

Out[3]:
```
True
```

Conditional Statements

if (boolean expression):

    //Do stuff

elif (other boolean expression):

note: elif is optional, can have as many elifs as necessary

    //Do other stuff

else:

note: else is optional, will execute only if the conditions in the “if” and “elif” statements are not true

    //Do other other stuff

Short-circuits, 'return', 'print'

- In python, expressions are evaluated from left to right
- With certain operations, a "short-ciruit" can happen if conditions are met
    - ex: True or 1/0 -> "or" only requires 1 True, so the expression is done evaluating before 1/0 can trigger an error.

- **'return'** is a very important and special keyword in python
    - all statements with return will short-circuit the function afterwards
    - It's python's functional way to pass a value out of a function
    - not every function needs a return (but most do)

- **'print'** displays some object (int, str, bool, etc.) onto a console
    - commonly used for debugging, sometimes integral to the purpose of a function.
    - print's result is None (it doesn't "return" a meaningful value)

Checkpoint

Which terminal command(s) runs all doctests?

1. python doctest code.py
2. python -i doctest code.py
3. python -m doctest code.py
4. python -m -v doctest code.py

Checkpoint Solution

3 - python -m doctest code.py

(according to past final exam performances, I did in fact need to include this.)

Doctests

- Tests to check that your function works as intended
- denoted by the '>>> ' symbol (space included)!
- the line right after the '>>> ' represents the intended output
- well written doctests make sure your code is logically sound

to run doctests: terminal -> file location -> **python -m doctest [filename].py**

note: if you want to see the doctests you passed when you run them, add a '-v' at the end.

Assert Statements

- Used to evaluate written code
- **asserts** -> input validation (are the arguments the correct types?)
- Often combined with boolean functions (any(), all(), etc.) and list comp
- result should be a boolean (True = pass, False = error)
- check naive cases first, then more specific cases

Loops

Loops are used to **repeat computations** many times.

- Two types of loops:
    - While loop: Uses logical conditions, useful for when the number of iterations is unknown (as long as a condition is true, code will run).
    - For loop : Uses an iterable object (ex. list), usually for when the number repetition is known.

In [ ]:
```
while x is True:
    # do something
for value in x:
    # do something
```

Mutability

- Object is mutable if it can be changed after it is created
- If it can't, it is immutable
- Lists are **mutable**
- strings, tuples, and numbers are **immutable**

Lists, Tuples, Sets

List

- Mutable vector of values
- Can store any data type, multiple types at a time
- Elements are acccessed via indexing

Tuple

- **Immutable** vector of values
- all else equal to list

Set

- Mutable vector of values
- Only stores unique elements (removes duplicates)
- Order is not preserved

List Comprehension

- Shorthand method of writing for loops
- Syntax changes depending on use case
- can be nested, just like lists
- Can contain multiple for loops in one list comp

  Syntax

  - [x for x in iterable]
  - [x for x in iterable if (condition)]
  - [x if (condition) else y for x in iterable]
  - [x if (condition) else y if (condition) else z for x in iterable]

In [2]:
```
temp = [[1], [2,3], [4,5,6]]
[x for sub in temp for x in sub]
```

Out[2]:
```
[1, 2, 3, 4, 5, 6]
```

Indexing/Slicing

Indexing/slicing refers to accessing specific element(s) from an iterable object. Two of the most common cases for this are lists and strings. Indexing results in a copy (unless reassigned)!

- iterable[start:stop:skip] (start:inclusive, stop: NOT inclusive)
- not every section needs to be specified (can just use start or stop or skip)
- Trying to access an index that doesn't exist in the list will result in an error
- Slicing beyond the range will yield an empty output

In [4]:
```
lst = list(range(2,7))
print("original list: " + str(lst))
print("reversed list: " + str(lst[::-1]))
print("the 2nd to 4th element: " + str(lst[2:4]))
print("every third element from the 1st to 10th element: " + str(lst[1:
print("slicing outside of range: " +  str(lst[11:]))
```

```
original list: [2, 3, 4, 5, 6]
reversed list: [6, 5, 4, 3, 2]
the 2nd to 4th element: [4, 5]
every third element from the 1st to 10th element: [3, 6]
slicing outside of range: []
```

Dictionaries

- Mutable storage of key, value pairs
- Can store any data type, multiple at a time
- Elements are acccessed via keys (dct[key])
- keys must be **hashable** and **unique**

methods

- accessing keys (as a list) -> dict.keys()
- accessing values (as a list) -> dict.values()
- accessing key,value pairs (as a list of tuples) -> dict.items()

note: hashablility correlates to the stability of the data - essentially, **data that can't change is hashable** (int, str, tuple, etc.) while **data that can change is not hashable (list, dictionary). Basically, it's all about mutability!**

Dictionary Comprehension

- Fancy, shorthand method of populating dictionaries
- Syntax changes depending on use case

Syntax

- basically the same as list comp, but now it expects key:value
- can include a list comp!

In [3]:
```
data = ['a','b','c','d','e']
{i:data[i] for i in range(len(data)) if i%2==0}
```

Out[3]:
```
{0: 'a', 2: 'c', 4: 'e'}
```

Files

- storage for data (csv, txt, json, parquet, etc.)
- unique methods to access within code

Access Modes

Write : 'w' -> every time the file is opened in write mode, the file is wiped. Calling file.write() will add in your data.

Append : 'a' -> file.write() will append your data to what existed in the file beforehand.

Read : 'r' -> no writing privilege, can only pull the data from the file with relevant methods.

Checkpoint

What happens when I try to open a file in my current folder that doesn't exist yet in write mode?

Checkpoint Solution

Python will automatically write an empty file with the provided filename.

Text Processing

reading data:

- file.read() -> reads in all the data as a single string
- file.readline() -> reads in data line by line (has to be recalled)
- file.readlines() -> reads in all the data as a list where each line is another element of the list

After reading in the data, you can transform it however you'd like, and then rewrite it back into the file using .write() (if this is relevant).

In [10]:
```
with open('files/sample.txt', 'r') as f:
    print(f.read())
with open('files/sample.txt', 'r') as f:
    print(f.readlines())
```

```
Final Exam is coming up!
Good luck!
['Final Exam is coming up!\n', 'Good luck!']
```

Midterm 2 Content

- lambda/map/filter
- HOF
- advanced argument passing
- time complexity
- recursion

Lambda Functions

- known as anonymous functions (their functions are so simple, they don't need a name)
- syntax: lambda (input): (some operation)
- Lambdas cannot take in `for` or `return`

In [8]:
```
lambda x: return x
```

```
  Cell In[8], line 1
    lambda x: return x
              ^
SyntaxError: invalid syntax
```

In [14]:
```
lambda x: for i in range(len(x))
```

```
  Cell In[14], line 1
    lambda x: for i in range(len(x))
              ^
SyntaxError: invalid syntax
```

Map

Map - **Syntax: map(function, iterable)**

- Map allows you to apply a function to all elements to an iterable input
- very common to use a lambda function as the function to apply
- returns an iterator through the iterable object, applying the function as it traverses

Filter

Filter - **Syntax: filter(function, iterable)**

- Filter takes in a function that returns a boolean and only keeps elements that satisfy the function (i.e. return True).
- Very common to use a lambda function as the function to apply, but keep in mind the function **must return a boolean**.
- Returns an iterator through the iterable object that only yields values that pass the function.

  I literally cannot emphasize this more, Filter's lambda has to return a boolean

HOF

- Algorithm design framework to create generalized code
- Functions that either return functions or use other functions
- Helper functions!
- Many uses, including abstraction, scope protection, etc.

*args

- Used when an unknown number of arguments will be passed into a function
- Denoted by * preceding the name in the method header
- processed in a similar manner to a list

In [9]:
```
def summation(*nums):
    return sum(nums)
print(summation())
print(summation(1,2,3,4,5))
```

```
0
15
```

**kwargs

- Used when an unknown number of **keyworded** arguments will be passed into a function
- Denoted by ** preceding the name in the method header
- processed in a similar manner to a dictionary

In [10]:
```
def create_dct(**entry):
    return dict(entry)
print(create_dct())
print(create_dct(marina=1, langlois=2))
```

```
{}
{'marina': 1, 'langlois': 2}
```

default_arguments

- Basically normal arguments, but with a default value
- if no value is passed, default value is set
- if a value is passed, default value is overwritten

note: lecture order

Complexity Fundamentals

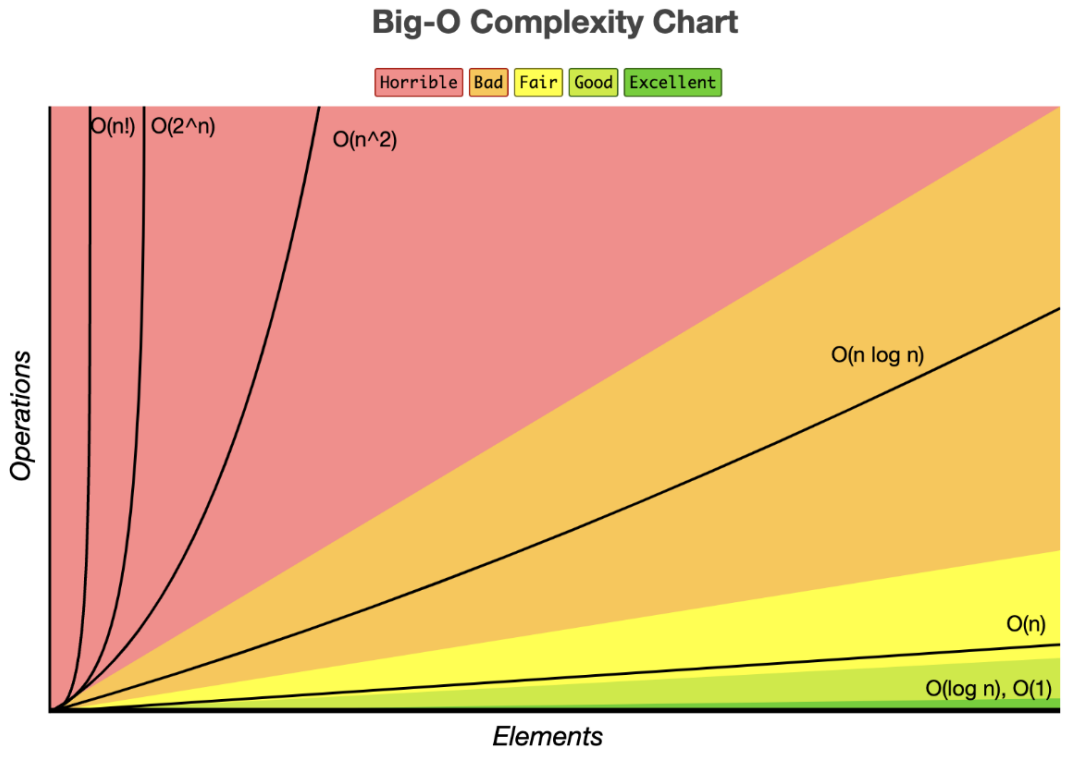
1. Code should be quantified into big O values
2. Nested code will have compounded big O values
3. The largest term dictates the growth rate (i.e. only largest term matters)
4. Constants are irrelevant
5. big O analysis uses similar ideas to calculus and limits - reference your math knowledge

Time Complexity

Utilize mathematical principles to classify code as runtime families to quantify their relative efficiency

tips:

1. Always look for "hallmark features" (ex. if I see i // 2, there's probably log involved)
2. If there are loops, check the iteration count AND the inside operations (don't assume n runtime)
3. Order of Growth follows mathematical principles. Only consider the largest term (without constants)


Big-O Complexity Chart
Horrible
Bad
Fair
Good
Excellent
O(n!)
O(2^n)
O(n^2)
O(n log n)
O(n)
O(log n), O(1)
Operations
Elements

source

Checkpoint

What is the runtime of the following code?

```
for _ in range(n, n^2, 1):
    print('hi')
```

Checkpoint Solution

$$O(n^2)$$

Does $n^2 - n$ become n or n^2? desmos

Recursion - Base Case

Base case(s) are regarded as the most important part of a recursive function. They determine the stop point for recursion and begin the argument passing up the "stack" of recursive calls. Without a well written base case, recursion will either never end or end incorrectly. When writing recursion questions, always start with determining the base case.

Recursion - Recursive Calls

The crux of a recursive function working is the recursive calls. These calls will repeat until the base case is reached, creating the "stack" of recursive calls that will begin resolving at the base case. Keep in mind when writing recursive calls that every call needs to trend towards the base case.

New Content

- classes
- inheritance
- special methods
- ASCII

Classes

- aggregate code into function bodies
- custom defined objects for specialized use

In [11]:
```
class phone:
    """
    Class representation of a regular phone.
    """
    pass
```

Constructors

- denoted by __init__ (special function)
- should ingest self as the first parameter (ALWAYS)
- populates instance with attributes
- if no constructor is explicitly defined, a default one is used

Working with self

- Think of classes as a blueprint and everytime you create an instance of one, you've produced a "physical" manifestation.
- We use the self keyword to interact with THIS specific instance of the class.
- Try to think of 'self' as referencing a **specific, singular** instance of the class. Every method that works with a specific instance's values must be passed in self as an argument.

In [18]:

```
class phone:
    """
    Class representation of a regular phone.
    """
    id_num = 1 # class variable
    def __init__(self, maker, version, owner):
        self.maker = maker
        self.version = version
        self.owner = owner
        self.id = phone.id_num
        phone.id_num+=1
        # instance variables
        self.apps = []
        self.free_memory = 800

    def install_app(self, app, memory):
        if self.free_memory - memory >= 0:
            self.apps.append(app)
            self.free_memory -= memory
            return True
        return False # class method
```

Inheritance

- classes can have a "parent-child" relationship
- child class(es) "inherit" methods from their parent class
- use "is-a" paradigm to distinguish; given a parent class phone and a child class pearphone:
    - pearphones are phones (child is a parent)
    - but not all phones are pearphones (parents are not children)
- Though not required, child classes can **overwrite** methods of their parent class
- if certain things are to be retained, super() is a useful function to use

note: super refers to the direct parent of a class

In [20]:

```
class pearphone(phone):
    def __init__(self, maker, version, owner, age):
        # self is implicitly passed with super()
        super().__init__(maker, version, owner)
        self.age = age

        self.apps = []
        self.free_memory = 800

    def install_app(self, app, memory):
        '''install_app but better (whoo pear phones!)'''
        if self.free_memory - memory//2 >= 0:
            self.apps.append(app)
            self.free_memory -= memory//2
            return True
        return False
```

Multiple Inheritance

- a class can inherit from multiple parent classes
- the order you list classes determines the order in which methods are inherited
    - (left to right, first encounter = inherit)

In [21]:

```
class black:
    def __init__(self, name):
        self.name = name
    def fizz(self, num):
        return num
    def buzz(self):
        return 'something idk'
class berry:
    def __init__(self, name):
        self.name = name
    def fizz(self, num):
        return num*2
    def foo(self, string):
        return string*2

class blackberry(black, berry):
    def __init__(self, name):
        self.name = name
    def buzz(self):
        return 'not idk'
```

In [23]:
```
phone = blackberry('bankrupt')
print(f'fizz result is: {phone.fizz(4)}')
print(f'buzz result is: {phone.buzz()}')
print(f'foo result is: {phone.foo("jingle")}')
```

```
fizz result is: 4
buzz result is: not idk
foo result is: jinglejingle
```

fizz is inherited from class black because it was first in the order of classes passed for inheritance (even though the same method exists in class berry).

buzz was overwritten and foo was inherited from class berry.

Special Methods

- Unique class methods that impose specific functionality
- Denoted by __ prepending and appending method names
- The one you're most familiar with is __init__
- Also called Dunder Methods!

__str__

- human readable representation of a class
- invoked when the string representation of a class is necessary (i.e. in a print or casted to a string)
- does not invoke __repr__

__repr__

- computer/technical representation of a class
- commonly written so that the returned value can be used to recreate the object
- if no __str__ is implemeneted, __repr__ will be used in lieu

__(lt, gt, eq, etc.)__

- encode operation between class instances

In [12]:
```
class phone:
    def __init__(self, name, owner, memory):
        self.name = name
        self.owner = owner
        self.memory = memory

    def __repr__(self):
        return f'phone("{self.name}", "{self.owner}", {self.memory})'

    def __lt__(self, other_phone):
        return self.memory < other_phone.memory

    def __eq__(self, other_phone):
        return self.name == self.name
```

In [13]:
```
iphone = phone('iPhoneIX', 'nikki',800)
samsung = phone('SamsungEarth', 'nikki',1600)
print(f'is the iphone less than the samsung (memory): {iphone<samsung}'
print(f'are the two phones the same (name): {iphone==samsung}')
```

```
is the iphone less than the samsung (memory): True
are the two phones the same (name): True
```

Exceptions

- Python class that represents Errors
- Triggered by any event that disrupts normal program flow
- utilizes `raise` keyword

Common Exception Types and Cases

- **KeyError** - related to dictionaries; attempted access using a key not present in the object
- **IndexError** - related to lists/strings; attempted acccess of an index that's out of range
- **TypeError** - attempt to unify non - matching data types (ex. str + int) or attempt to access unknown attribute of datatype
- **FileNotFoundError** - related to files; attempted to open a file name that can't be found

raise

python keyword to throw an error.

syntax: raise [exception class](error message // optional)

In [24]:
```
def bar_entry(age):
    if age < 21:
        raise ValueError("too young to drink...")
bar_entry(18)
```

```
---------------------------------------------------------------------------
ValueError                                Traceback (most recent call last)
Cell In[24], line 4
      2     if age < 21:
      3         raise ValueError("too young to drink...")
----> 4 bar_entry(18)

Cell In[24], line 3, in bar_entry(age)
      1 def bar_entry(age):
      2     if age < 21:
----> 3         raise ValueError("too young to drink...")

ValueError: too young to drink...
```

try except else

- Exceptions can be handled in `try-except` blocks, preventing code from terminating the moment an error happens.
- `Except` generally handles specific error classes (ex. except `zerodivisionerror`)
- just like with files, it's common to specify a handle for easier processing (`as e`)
- `else` is code that's ran in the case of no errors occurring

In [25]:
```
def attempt_bar_entry(age):
    try:
        bar_entry(age)
    except ValueError as e:
        print(e)
    else:
        print('welcome in!')

attempt_bar_entry(18)
print('------------------------------------')
attempt_bar_entry(21)
```

```
too young to drink...
------------------------------------
welcome in!
```

try-except vs assert

Assert statements are used to validate inputs and prevent logical errors. Try-except is used to catch error generating inputs / code.

Ex. Asserts can't ascertain that a filepath exists, while try-except can prevent errors like this from happening

ASCII

- ASCII is a character encoding standard that assigns a unique numeric value to each character.
- `ord()` to convert a single character to its corresponding ASCII value.
- `chr()` function to convert an ASCII value back to its corresponding character

ASCII (cont.)

Dec	Hx	Oct	Char	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL (null)	32	20	040		Space	64	40	100	@	@	96	60	140	`	`
1	1	001	SOH (start of heading)	33	21	041	!	!	65	41	101	A	A	97	61	141	a	a
2	2	002	STX (start of text)	34	22	042	"	"	66	42	102	B	B	98	62	142	b	b
3	3	003	ETX (end of text)	35	23	043	#	#	67	43	103	C	C	99	63	143	c	c
4	4	004	EOT (end of transmission)	36	24	044	$	$	68	44	104	D	D	100	64	144	d	d
5	5	005	ENQ (enquiry)	37	25	045	%	%	69	45	105	E	E	101	65	145	e	e
6	6	006	ACK (acknowledge)	38	26	046	&	&	70	46	106	F	F	102	66	146	f	f
7	7	007	BEL (bell)	39	27	047	'	'	71	47	107	G	G	103	67	147	g	g
8	8	010	BS (backspace)	40	28	050	(	(	72	48	110	H	H	104	68	150	h	h
9	9	011	TAB (horizontal tab)	41	29	051	)	)	73	49	111	I	I	105	69	151	i	i
10	A	012	LF (NL line feed, new line)	42	2A	052	*	*	74	4A	112	J	J	106	6A	152	j	j
11	B	013	VT (vertical tab)	43	2B	053	+	+	75	4B	113	K	K	107	6B	153	k	k
12	C	014	FF (NP form feed, new page)	44	2C	054	,	,	76	4C	114	L	L	108	6C	154	l	l
13	D	015	CR (carriage return)	45	2D	055	-	-	77	4D	115	M	M	109	6D	155	m	m
14	E	016	SO (shift out)	46	2E	056	.	.	78	4E	116	N	N	110	6E	156	n	n
15	F	017	SI (shift in)	47	2F	057	/	/	79	4F	117	O	O	111	6F	157	o	o
16	10	020	DLE (data link escape)	48	30	060	0	0	80	50	120	P	P	112	70	160	p	p
17	11	021	DC1 (device control 1)	49	31	061	1	1	81	51	121	Q	Q	113	71	161	q	q
18	12	022	DC2 (device control 2)	50	32	062	2	2	82	52	122	R	R	114	72	162	r	r
19	13	023	DC3 (device control 3)	51	33	063	3	3	83	53	123	S	S	115	73	163	s	s
20	14	024	DC4 (device control 4)	52	34	064	4	4	84	54	124	T	T	116	74	164	t	t
21	15	025	NAK (negative acknowledge)	53	35	065	5	5	85	55	125	U	U	117	75	165	u	u
22	16	026	SYN (synchronous idle)	54	36	066	6	6	86	56	126	V	V	118	76	166	v	v
23	17	027	ETB (end of trans. block)	55	37	067	7	7	87	57	127	W	W	119	77	167	w	w
24	18	030	CAN (cancel)	56	38	070	8	8	88	58	130	X	X	120	78	170	x	x
25	19	031	EM (end of medium)	57	39	071	9	9	89	59	131	Y	Y	121	79	171	y	y
26	1A	032	SUB (substitute)	58	3A	072	:	:	90	5A	132	Z	Z	122	7A	172	z	z
27	1B	033	ESC (escape)	59	3B	073	;	;	91	5B	133	[	[	123	7B	173	{	{
28	1C	034	FS (file separator)	60	3C	074	<	<	92	5C	134	\	\	124	7C	174			|
29	1D	035	GS (group separator)	61	3D	075	=	=	93	5D	135	]	]	125	7D	175	}	}
30	1E	036	RS (record separator)	62	3E	076	>	>	94	5E	136	^	^	126	7E	176	~	~
31	1F	037	US (unit separator)	63	3F	077	?	?	95	5F	137	_	_	127	7F	177	&#127;	DEL

In [2]:
```
print(ord('A'))
print (chr(65))
```

```
65
A
```

is vs ==

- The `==` operator is used to check the equality of the values of two objects
- The `is` operator is used to check if two variables refer to the same object in memory

tl;dr: `==` checks for equality of values, while `is` checks for identity

In [4]:
```
a = [1,2,3]
b = [1,2,3]
c = a
print(a == b)
print(a is b)
print(c is a)
```

```
True
False
True
```

Good luck on the final!

Please fill out the survey in today's attendance assignment