FACEBOOK PREP

> ***TOP RESOURCE: [GAYLE SLIDES]()***
>
> > *"Interviewers rarely try to test knowledge of anything but the most basic Computer Science concepts. Instead, they are evaluating your ability to break down a tricky problem and to solve problems using what you do know."*

BEHAVIOR QUESTIONS

> ### *BEHAVIOR*
>
> ```
> HINT: BE HUMBLE, BE A GREAT TEAMMATE, BE GREAT ENGINEER, BE PASSIONATE, BE KNOWLEDGEABLE, BE CHALLENGEABLE
> - SHOW YOU'RE SMART AND YOU CAN CODE
> ```
>
> ### *PITCH*
>
> ```
> HINT: Memorize your CV: career, studies, accomplishment, hobbies, projects and past work.
>
> I'M A MECHATRONICS ENGINEER WITH A PHD IN IT&C WITH A DISSERTATION FOCUSED ON AI AND MULTI-ROBOT CONTROL.
> SINCE GRAD SCHOOL, I'VE BEEN DOING TECH FOR SOCIAL GOOD INCLUDING CIC.MX, A NON-PROFIT AWARDED BY ERIC
> SCHMIDT'S NEW DIGITAL ERA GRANTS, WHICH WERE GIVEN TO THOSE PROMISING SOCIAL CAUSES WITH TECH BASIS. I'VE
> DONE SEVERAL GEOREFERENCING PROJECTS CLOSE TO GOVERNMENT AND CIVIL SOCIETY ORGANIZATIONS, THOSE CONFORM MY
> STRONGEST BASE IN SQL AND POSTGRESQL DATABASES. THEN I LEFT CIC.MX TO BUILD A STARTUP WITH A COUPLE OF
> FRIENDS WHERE WE ARE BUILDING AN ALL-ACCESS API AND EASY TO READ DATA VISUALIZATIONS FROM OUR STATE-RUN
> ELECTRICITY PROVIDER. WE'VE SUCCESSFULLY PULLED DATA FROM EVERY USER AND THE SYSTEM IS READY TO SCALE AS
> ENGAGEMENT COMES. IN FACT THIS PROJECT MOTIVATED ME TO BUILD A MATERIAL-DESIGN BOILERPLATE, WHICH IS NOW
> MY BIGGEST AND MOST PROMISING TECH ADVENTURE FOR EMPOWERING STARTUPS, ENTREPRENEURS AND NON-PROFITS DEV
> TEAMS. THIS IS MOST OF MY TIME OUT OF WORK THAT IS STILL RELATED TO TECHNOLOGY, BESIDES, I'VE JUST
> BECOME A DAD !
>
> * DEEP DIVE INTO DISSERTATION AS A HARD|COOL PROJECT (HASHTABLE & JSON BASED TRANSFERS AND ALLOCATIONS)
> * DEEP DIVE INTO MBOILERPLATE AS A HARD|COOL PROJECT (NOSQL, CLOUD BASED, SCALABLE, EXTENDIBLE, LOW-COST:
> SHOW
>   HOW I LOVE TO BUILD STUFF FAST)
> * THINK OF INCLUDING NIGHTS AND WEEKENDS: OPENCITYAPPS.MX, IPAB, EDUCTIVISM, EMULATED CDMA, NETWORK
> PALS...
> ```

PROCESS

```
1. GET INTERVIEW OUTFIT DRY CLEANED IF NECESSARY
2. REHEARSE STORIES FROM THE INTERVIEW PREP GRID
3. RE-READ 5 ALGORITH APPROACHES
4. CONTINUE TO PRACTICE UNTIL DAY OF INTERVIEW
5. REVIEW LIST OF TYPICAL MISTAKES
6. PRINT 10 COPIES OF MOST-UPDATED RESUME AND PUT THEM INTO FOLDER
7. AFTER: WRITE THANK YOU NOTE TO RECRUITER

DRESS CODE: KHAKIS, SLACKS OR NICE JEANS, POLO SHIRT OR DRESS SHIRT.
```

FACEBOOK

```
1. BE ENTREPRENEURIAL
2. ENHANCE A LOT MBOILERPLATE, SHOW HOW I LOVE TO BUILD STUFF FAST.
3. DEMONSTRATE "NINJA-SKILLS":
    3.1 HACK TOGETHER ELEGANT AND SCALABLE SOLUTIONS
    3.2 SHOW HOW YOU GET THINGS DONE
4. SHOW PASSION FOR AQUILA AND THE HARDWARE + SOFTWARE + HUMANITIES CROSSROADS
```

SAMPLE QUESTIONS

```
1. Tell Me About a Time When You Gave a Presentation to a Group of People Who Disagreed with You
2. Tell Me About the Biggest Mistake You Made on a Past Project
3. Tell Me About a Time When You Had to Deal with a Teammate Who Was Underperforming
4. Tell Me About a Time When You had to Make a Controversial Decision
5. Tell Me About a Time When You had to Use Emotional Intelligence to Lead
```

TECHNICAL QUESTIONS

SKIR:

```
Scope the problem, Key clues and components, Issues, Repairs
```

DRIVE:

```
Lead the process and be open about issues, Do pseudocode before code
```

TEAMWORK:

```
Tweak, be open to feedback
```

PRACTICE:

```
Interview questions, coding on whiteboard, algorithms, design patterns
```

KNOWLEDGE QUESTIONS

```
HINT: REVIEW CS FUNDAMENTALS AND KEY CONCEPTS

- Think on how-to SQL indexing, how-to design patterns, how-to webapp2
```

MEMORY (STACK VS HEAP)

The Stack: *global and local scope variables*

```
    What is the stack?
    It's a special region of your computer's memory that stores temporary
    variables created by each function (including the main() function). The
    stack is a "FILO" (first in, last out) data structure, that is managed and
    optimized by the CPU quite closely. Every time a function declares a new
    variable, it is "pushed" onto the stack. Then every time a function exits,
    all of the variables pushed onto the stack by that function, are freed (that
    is to say, they are deleted). Once a stack variable is freed, that region of
    memory becomes available for other stack variables.

    The advantage of using the stack to store variables, is that memory is
    managed for you. You don't have to allocate memory by hand, or free it once
    you don't need it any more. What's more, because the CPU organizes stack
    memory so efficiently, reading from and writing to stack variables is very
    fast.

    To summarize the stack:

        - the stack grows and shrinks as functions push and pop local variables
        - there is no need to manage the memory yourself, variables are
          allocated and freed automatically
        - the stack has size limits
        - stack variables only exist while the function that created them, is
          running

    Pros and cons:

          very fast access
          don't have to explicitly de-allocate variables
          space is managed efficiently by CPU, memory will not become fragmented
          local variables only
          limit on stack size (OS-dependent)
          variables cannot be resized
```

The Heap: *global scope variables making use of pointers (*)*

```
    What is the heap?
    The heap is a region of your computer's memory that is not managed
    automatically for you, and is not as tightly managed by the CPU. It is a
    more free-floating region of memory (and is larger). To allocate memory on
    the heap, you must use malloc() or calloc(), which are built-in C
    functions. Once you have allocated memory on the heap, you are responsible
    for using free() to deallocate that memory once you don't need it any more.
    If you fail to do this, your program will have what is known as a memory
    leak. That is, memory on the heap will still be set aside (and won't be
    available to other processes). As we will see in the debugging sectio,
    there is a tool called valgrind that can help you detect memory leaks.

    Unlike the stack, the heap does not have size restrictions on variable size
    (apart from the obvious physical limitations of your computer). Heap memory
    is slightly slower to be read from and written to, because one has to use
    pointers to access memory on the heap.

    Unlike the stack, variables created on the heap are accessible by any
    function, anywhere in your program. Heap variables are essentially global
    in scope.

    Pros and cons:
        variables can be accessed globally
        no limit on memory size
        (relatively) slower access
        no guaranteed efficient use of space, memory may become fragmented over time as blocks of memory are
allocated,
        then freed
        you must manage memory (you're in charge of allocating and freeing variables)
        variables can be resized using realloc()
```

Memory management in Python

```
    Memory management in Python involves a private heap containing all Python objects and data structures.
    The management of this private heap is ensured internally by the Python memory manager. The Python memory
manager
    has different components which deal with various dynamic storage management aspects, like sharing,
segmentation,
    preallocation or caching.

    It is important to understand that the management of the Python heap is performed by the interpreter
itself and that
    the user has no control over it, even if she regularly manipulates object pointers to memory blocks inside
that
    heap. The allocation of heap space for Python objects and other internal buffers is performed on demand by
the
    Python memory manager through the Python/C API functions.

    locals() & gloabls() built-in functions output a dictionary of all in-memory variables
```

BIG-O

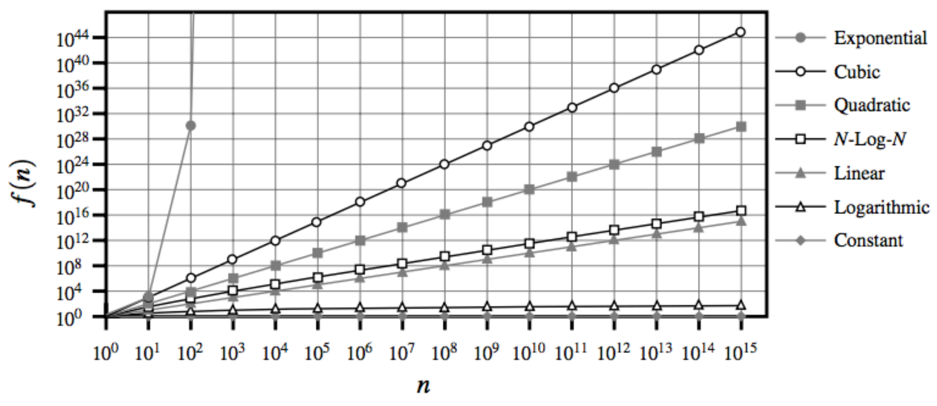


Figure 3.4: Growth rates for the seven fundamental functions used in algorithm analysis. We use base $a = 2$ for the exponential function. The functions are plotted on a log-log chart, to compare the growth rates primarily as slopes. Even so, the exponential function grows too fast to display all its values on the chart.

Data Structure Operations

Data Structure	Time Complexity								Space Complexity
	Average				Worst				Worst
	Access	Search	Insertion	Deletion	Access	Search	Insertion	Deletion	
Array	O(1)	O(n)	O(n)	O(n)	O(1)	O(n)	O(n)	O(n)	O(n)
Stack	O(n)	O(n)	O(1)	O(1)	O(n)	O(n)	O(1)	O(1)	O(n)
Singly-Linked List	O(n)	O(n)	O(1)	O(1)	O(n)	O(n)	O(1)	O(1)	O(n)
Doubly-Linked List	O(n)	O(n)	O(1)	O(1)	O(n)	O(n)	O(1)	O(1)	O(n)
Skip List	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(n)	O(n)	O(n)	O(n)	O(n log(n))
Hash Table	-	O(1)	O(1)	O(1)	-	O(n)	O(n)	O(n)	O(n)
Binary Search Tree	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(n)	O(n)	O(n)	O(n)	O(n)
Cartesian Tree	-	O(log(n))	O(log(n))	O(log(n))	-	O(n)	O(n)	O(n)	O(n)
B-Tree	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(n)
Red-Black Tree	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(n)
Splay Tree	-	O(log(n))	O(log(n))	O(log(n))	-	O(log(n))	O(log(n))	O(log(n))	O(n)
AVL Tree	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(n)

Array Sorting Algorithms

Algorithm	Time Complexity			Space Complexity
	Best	Average	Worst	Worst
Quicksort	O(n log(n))	O(n log(n))	O(n^2)	O(log(n))
Mergesort	O(n log(n))	O(n log(n))	O(n log(n))	O(n)
Timsort	O(n)	O(n log(n))	O(n log(n))	O(n)
Heapsort	O(n log(n))	O(n log(n))	O(n log(n))	O(1)
Bubble Sort	O(n)	O(n^2)	O(n^2)	O(1)
Insertion Sort	O(n)	O(n^2)	O(n^2)	O(1)
Selection Sort	O(n^2)	O(n^2)	O(n^2)	O(1)
Shell Sort	O(n)	O((nlog(n))^2)	O((nlog(n))^2)	O(1)
Bucket Sort	O(n+k)	O(n+k)	O(n^2)	O(n)
Radix Sort	O(nk)	O(nk)	O(nk)	O(n+k)

Graph Operations

Node / Edge Management	Storage	Add Vertex	Add Edge	Remove Vertex	Remove Edge	Query
Adjacency list	O(|V|+|E|)	O(1)	O(1)	O(|V| + |E|)	O(|E|)	O(|V|)
Incidence list	O(|V|+|E|)	O(1)	O(1)	O(|E|)	O(|E|)	O(|E|)
Adjacency matrix	O(|V|^2)	O(|V|^2)	O(1)	O(|V|^2)	O(1)	O(1)
Incidence matrix	O(|V| · |E|)	O(|V| · |E|)	O(|V| · |E|)	O(|V| · |E|)	O(|V| · |E|)	O(|E|)

Heap Operations

Type	Time Complexity						
	Heapify	Find Max	Extract Max	Increase Key	Insert	Delete	Merge
Linked List (sorted)	-	O(1)	O(1)	O(n)	O(n)	O(1)	O(m+n)
Linked List (unsorted)	-	O(n)	O(n)	O(1)	O(1)	O(1)	O(1)
Binary Heap	O(n)	O(1)	O(log(n))	O(log(n))	O(log(n))	O(log(n))	O(m+n)
Binomial Heap	-	O(1)	O(log(n))	O(log(n))	O(1)	O(log(n))	O(log(n))
Fibonacci Heap	-	O(1)	O(log(n))	O(1)	O(1)	O(log(n))	O(1)

BIT MANIPULATION

```
    Implementation:
         N = int('10000000000',2)
         M = int('10011',2)
         binary_m = bin(M)  #str in the form '0b10011'

    x << y
    Returns x with the bits shifted to the left by y places (and new bits on the right-hand-side are
zeros).This is the same as multiplying x by 2**y.

    x >> y
    Returns x with the bits shifted to the right by y places. This is the same as dividing x by 2**y.

    x & y
    Does a "bitwise and". Each bit of the output is 1 if the corresponding bit of x AND of y is 1, otherwise
it's 0.

    x | y
    Does a "bitwise or". Each bit of the output is 0 if the corresponding bit of x AND of y is 0, otherwise
it's 1.

    ~ x
    Returns the complement of x - the number you get by switching each 1 for a 0 and each 0 for a 1. This is
the same as -x - 1.

    x ^ y
    Does a "bitwise exclusive or". Each bit of the output is the same as the corresponding bit in x if that
bit in y is 0, and it's the complement of the bit in x if that bit in y is 1.
```

POWER OF 2

```
    2^7 = 128
    2^10 = ~1000 (1KB)
    2^20 = ~1000000 (1MB)
    2^30 = ~1000000000 (1GB)
    2^40 = ~1000000000000 (1TB)
```

RECURSION AND MEMOIZATION / DYNAMIC PROGRAMMING

Typical use:

```
    When there's a problem that can be built off of sub-problems.

    All recursive code can be implemented iteratively, although sometimes the code to do so is much more
complex. Before diving into recursive code, ask yourself how hard it would be to implement it iteratively, and
discuss the trade-offs with your interviewer.

    Hints for recursion:

    "Design an algorithm to compute the nth..."

    "Write code to list the first n"..."

    "Implement a method to compute all.. ."

    EXAMPLE:

    def hanoi(n, source, helper, target):
        print "hanoi( ", n, source, helper, target, " called"
        if n > 0:
            # move tower of size n - 1 to helper:
            hanoi(n - 1, source, target, helper)
            # move disk from source peg to target peg
            if source[0]:
                disk = source[0].pop()
                print "moving " + str(disk) + " from " + source[1] + " to " + target[1]
                target[0].append(disk)
            # move tower of size n-1 from helper to target
            hanoi(n - 1, helper, source, target)

    source = ([4,3,2,1], "source")
    target = ([], "target")
    helper = ([], "helper")
    print source, helper, target
    hanoi(len(source[0]),source,helper,target)
    print source, helper, target
```

How-to Bottom-Up Recursion:

```
    1. Solve a simple case for single element.

    2. Extend previous solution for two elements.

    3. Then extend for three elements and so on. Typically fourth case is enough.

    The key here is to think about how you can build the solution for one case
    off of the previous case.
```

How-to Top-Down Recursion:

```
    1. Think how to divide proble for case N into subproblems.

    Be careful of overlap between the cases.
```

Slow recursive

```
    def fib(n):
        return n if n < 2 else fib(n-2) + fib(n-1)
```

Memoized

```
Memoisation is a technique used in computing to speed up programs. This is accomplished by memorizing the
    calculation results of processed input such as the results of function calls. If the same input or a
function call
    with the same parameters is used, the previously stored results can be used again and unnecessary
calculation are
    avoided. In many cases a simple array is used for storing the results, but lots of other structures can be
used as
    well, such as associative arrays, called hashes in Perl or dictionaries in Python.

    def memoize(f):
        memo = {}
        def helper(x):
            if x not in memo:
                memo[x] = f(x)
            return memo[x]
        return helper

    @memoize
    def fib(n):
        return n if n < 2 else fib(n-2) + fib(n-1)
```

MATH AND PROBABILITY

Hints

```
    1. Be careful with the difference in precision between floats and doubles.
    2. Don't assume that a value (such as the slope of a line) is an int unless you've been told so.
    3. Unless otherwise specified, do not assume that events are independent (or mutually exclusive). You
should be careful, therefore, of blindly multiplying or adding probabilities.
```

Prime numbers

```
Every positive integer can be decomposed into a product of primes. Thus, in order for a number x to divide a
number y (written x\y, or mod(y, x) = 0), all primes in x's prime factorization must be in y's prime
factorization.

A list of primes a.k.a. The Sieve of Eratosthenes in Python:

    def sieveOfEratosthenes(n):
        """return the list of the primes < n."""

        if n <= 2:
            return []
        sieve = range(3, n, 2)
        top = len(sieve)
        for si in sieve:
            if si:
                bottom = (si*si - 3) // 2
                if bottom >= top:
                    break
                sieve[bottom::si] = [0] * -((bottom - top) // si)
        return [2] + [el for el in sieve if el]
```

Probability

```
A conditional 'intersection' of probabilities is calculated as the product of two or more probabilities
(logical AND). Example given 1 to 10 (inclusive):

        P(A and B)=P(A)*P(B)
        P(x is even and x <= 5)
        = P(x is even given x <= 5) P(x <= 5) = (2/5) * (1/2)
        = 1/5


A conditional 'join' of probabilities is calculated as the sum of two or more probabilities (logical OR) minus
the intersection. Example given 1 to 10 (inclusive):

        P(A or B)=P(A)+P(B)-P(A and B)
        P(x is even or x <=5)
        = P(x is even) + P(x <= 5) - P(x is even and x <= 5)
        = (1/2) + (1/2) - (1/5)
        = 4/5

Remember:
     - independence means P(A and B)= P(A)*P(B).
     - mutual exclusivity means P(A or B)=P(A)+P(B), since P(A and B)=0.
```

Permutations: *(order does matter)*

```
In mathematics, the notion of permutation relates to the act of arranging all the members of a set into some
sequence or order, or if the set is already ordered, rearranging (reordering) its elements, a process called
permuting.

    # (n)!/(n-r)! for n elements and r selections
    permutations('ABCD', 2)
    AB AC AD BA BC BD CA CB CD DA DB DC
```

Combinations: *(order doesn't matter)*.

```
Combinations refer to the combination of n things taken k at a time without repetition. To refer to
combinations in which repetition is allowed, the terms k-selection, k-multiset, or k-combination with
repetition are often used.

    #(n)!/(r!(n-r)!) for n elements and r selections
    combinations('ABCD', 2)
    AB AC AD BC BD CD

    #(n+r-1)!/(r!(n-1)!) for n elements and r selections
    combinations_with_replacement('ABCD', 2)
    AA AB AC AD BB BC BD CC CD DD
```

OBJECT ORIENTED DESIGN (REAL-LIFE OBJECTS)

```
The implementation of classes and methods to sketch out technical problems or real-life objects.
```

How-to approach OOD

```
    STEP 1. Handle ambiguity

            Ask for clarifications, refer any possible assumption.
            Who's gonna use? How's gonna be used?
            Most detailed perspective should ask for who, what, where, when, how and why.

    STEP 2. Define the core objects

            Just after having a clear picture of what we're designing, lets list the core objects that conform
our modeled solution.

    STEP 3. Analyze relationships

            Having more or less decided on our core objects, we now want to analyze the relationships between
the objects.
            Which objects are members of which other objects?
            Do any objects inherit from any others?
            Are relationships many-to-many or one-to-many?

    STEP 4. Investigate actions

            At this point, you should have the basic outline of your object-oriented design. What remains is
to consider the key actions that the objects will take and how they relate to each other. You may find that
you have forgotten some objects, and you will need to update your design.

    STEP 5. Shall we use any Design Pattern ?
```

Python class pattern

```
    class Progression(object):
        """ <CLASS DOCUMENTATION> Iterator producing a generic progression.
        Default iterator produces the whole numbers 0, 1, 2, ...
        """

        def __init__(self, start=0):
            """<CONSTRUCTOR> Initialize current to the first value of the progression."""
            self._current = start

        def _advance(self):
            """ <INTERNAL METHOD WITH NO RETURN> Update self. current to a new value.
            This should be overridden by a subclass to customize progression.
            By convention, if current is set to None, this designates the
            end of a finite progression.
            """
            self._current += 1

        def __next__(self):
            """ <INTERNAL METHOD WITH RETURN> Return the next element, or else raise StopIteration error."""
            if self._current is None: # our convention to end a progression
                raise StopIteration( )
            else:
                answer = self._current # record current value to return
                self._advance( ) # advance to prepare for next time
            return answer # return the answer

        def __iter__(self):
            """ <CONVENTIONAL METHOD> By convention, an iterator must return itself as an iterator."""
            return self
        def __str__(self):
            """ <CONVENTIONAL METHOD> By convention, reduce string representation of vector."""
            return "'" + self + "'"

        def print_progression(self, n):
            """ <OUTPUT METHOD> Print next n values of the progression."""
            print(' '.join(str(self.__next__()) for j in range(n)))

    class ArithmeticProgression(Progression): # inherits from Progression
        """Iterator producing an arithmetic progression."""

        def __init__(self, increment=1, start=0):
            """<INHERITANCE> Create a new arithmetic progression.
            increment the fixed constant to add to each term (default 1)
            start the first term of the progression (default 0)
            """
            super(ArithmeticProgression, self).__init__(start) # initialize base class
            self._increment = increment

        def _advance(self): # override inherited version
            """Update current value by adding the fixed increment."""
            self._current += self._increment


    def main():
        print( "Default progression:" )
        Progression().print_progression(10)
        Progression().print_progression(8)
        print( "Arithmetic progression with increment 5:" )
        ArithmeticProgression(5).print_progression(10)
        print( "Arithmetic progression with increment 5 and start 2:" )
        ArithmeticProgression(5, 2).print_progression(10)

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

Singleton design pattern

```
    The Singleton pattern ensures that a class has only one instance and ensures access to the instance
through the application without instantiating it again.

    # the python metaclass approach
    ------

    class Singleton(type):
        def __call__(cls, *args, **kwargs):
            try:
                return cls.__instance
            except AttributeError:
                cls.__instance = super(Singleton, cls).__call__(*args, **kwargs)
                return cls.__instance

    class MySingleton(object):
        __metaclass__ = Singleton
```

Factory design pattern

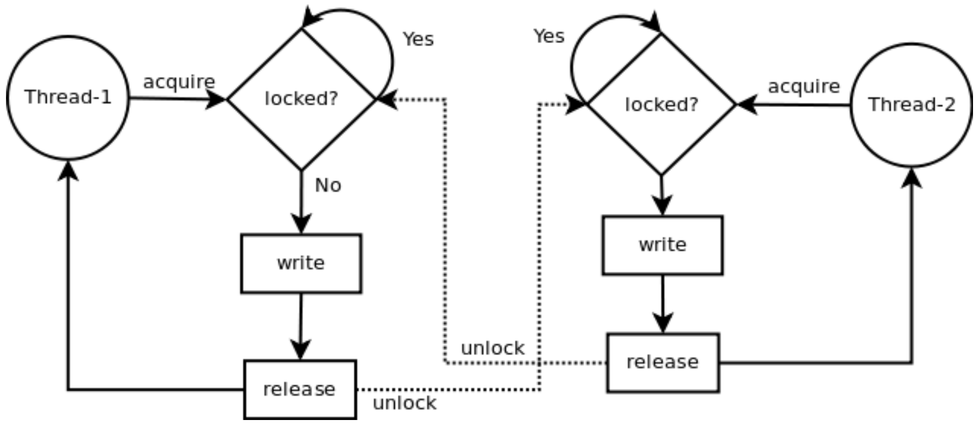
```
    The Factory pattern deals with the problem of creating objects without specifying the exact class of the
object to be created. You give a parameter in order to know which class to instantiate.

    class A(object):
        def __init__(self):
        self.a = "Hello"

    class B(object):
        def __init__(self):
        self.a = " World"

    myfactory = {
        "greeting" : A,
        "subject" : B,
    }

    >>> print myfactory["greeting"]().a
    Hello
```

THREADS AND LOCKS

```
    In computer science, a thread is used to run processes concurrently, meaning 2 or more sequences of
programmed instructions could be running at the same time, sharing memory and the values of its variables at
any given moment.

    Coordinating threads demands for additionals methods that ensure the concurrency won't affect the final
desired result. Here come synchronization concepts such as: lock, rlock, condition, semaphore, events and
queues.

        1. First of all, threading in python is through the threading.py standard module using the method
.start(), i.e.:

            import threading
            class FetchUrls(threading.Thread):
                """
                    Thread checking URLs.
                """

                def __init__(self, urls, output):
                    """
                        Constructor.

                        @param urls list of urls to check
                        @param output file to write urls output
                    """
                    threading.Thread.__init__(self)
                    self.urls = urls
                    self.output = output

                def run(self):
                    """
                        Thread run method. Check URLs one by one.
                    """
                    while self.urls:
                        url = self.urls.pop()
                        req = urllib2.Request(url)
                        try:
                            d = urllib2.urlopen(req)
                        except urllib2.URLError, e:
                            print 'URL %s failed: %s' % (url, e.reason)
                        self.output.write(d.read())
                        print 'write done by %s' % self.name
                        print 'URL %s fetched by %s' % (url, self.name)
```

2. Lock, used to enforce mutual exclusion and concurrency control to avoid a mess if doing same action like writing the same file, i.e.:

```
class FetchUrls(threading.Thread):
    ...

    def __init__(self, urls, output, lock):
        ...
        self.lock = lock

    def run(self):
        ...
        while self.urls:
            ...
            self.lock.acquire()
            print 'lock acquired by %s' % self.name
            self.output.write(d.read())
            print 'write done by %s' % self.name
            print 'lock released by %s' % self.name
            self.lock.release()
            ...
```



DATABASES

SQL Normalization: database that reduces data duplicity.

SQL Denormalization: databse that looks for highly scalable systems and faster queries (less joins).

NoSQL Leverages continual change in place, and speed of deployment.

DESIGN (recall How-to approach OOD)

```
SMALL DATABASE

        1. Handle ambiguity, find the level of detail or how general you should design.
        2. Define core objects, be aware that this information is typically the one that is redundant in
denormalized systems.
        3. Analyze relationships, outline core objects and their relations including one-to-many, one-to-one,
many-to-many.
        4. Investigate actions, define the most typical queries needed and re-structure if necessary.


LARGE DATABASE

        1. Follow the previous process but be redundant with most needed columns, denormalize your design.
        2. Don't be scared about duplicates, they're better than slow systems.
```

INDEXES

```
A database index is a data structure that improves the speed of data retrieval operations on a database table
at the cost of additional writes and storage space to maintain the index data structure.

Indexes are special lookup tables that the database search engine can use to speed up data retrieval. Simply
put, an index is a pointer to data in a table. An index in a database is very similar to an index in the back
of a book.

Typical use implies trees or dictionaries with unique keys (B+Trees) that endup being bitmaps that identify
data in a simpler representation.
```

SHARDING

```
A database shard is a horizontal partition of data in a database or search engine. Each individual partition
is referred to as a shard or database shard. Each shard is held on a separate database server instance, to
spread load.

Pros: reduced index size, which generally improves search performance.

Cons: heavier reliance on the interconnect between servers, increased latency when querying, issues of
consistency, more complex failover and backups.
```

NoSQL

```
Focuses on large-volume and semi-structured data. Alleviates the problems that RDBMS imposes and makes it easy
to work with large sparse data, but in turn takes away the power of transactional integrity and flexible
indexing and querying.

MongoDB 4th most popular in the world, pretty much as Google's Datastore NDB, PostgreSQL and Cassandra.
Leverage JSON or Binary-JSON (and even YAML and XML) structures instead of traditional relational databases
(RDBMS). Useful in big data and real-time web apps and really attractive for programming modern web
applications, which are subject to continual change in place, and speed of deployment is an important issue.

Google's Datastore NDB: Schemaless access, with SQL-like querying.

Classes:

    Column - JSONs with fixed properties: name, value and timestamp

    Document - most popular, flexible, designed to offer a richer experience with modern programming
techniques

    Key-value - associative arrays or tuples

    Graph - semantic queries and graph structures.

    Multi-model - may use graph, relational and key-value models.
```

TASK QUEUES

```
Tasks queues are an efficient and powerful tool for background processing; they allow your application to
define tasks, add them to a queue, and then use the queue to process them in aggregate.

Taskqueue lets applications to perform work outside of a user request, initiated by a user request. If an app
needs to execute some background work, it can use the Taskqueues to organize that work into small, discrete
units, called tasks. The app adds tasks to taskqueues to be executed later.
```

WEBAPP2 (Python WSGI)

```
A lightweight framework that allows you quickly build simple web applications for the Python 2.7 runtime.
webapp2 is compatible with the WSGI standard for Python web applications.

WSGI is a specification for a standardized interface between Web servers and Python Web
frameworks/applications. The goal is to provide a relatively simple yet comprehensive interface capable of
supporting all interactions between a Web server and a Web framework.

Pros:
    - I no longer have to worry about making my application run in multiple Web servers: most servers, and all
frameworks, are WSGI compliant.
    - WSGI is Python's Answer to Ruby On Rails
```

Why Cloud Computing ?

Automation – “Scriptable infrastructure”: You can create repeatable build and deployment systems by leveraging programmable (API-driven) infrastructure.

Auto-scaling: You can scale your applications up and down to match your unexpected demand without any human intervention.

Auto-scaling encourages automation and drives more efficiency.

Proactive Scaling: Scale your application up and down to meet your anticipated demand with proper planning understanding of your traffic patterns so that you keep your costs low while scaling.

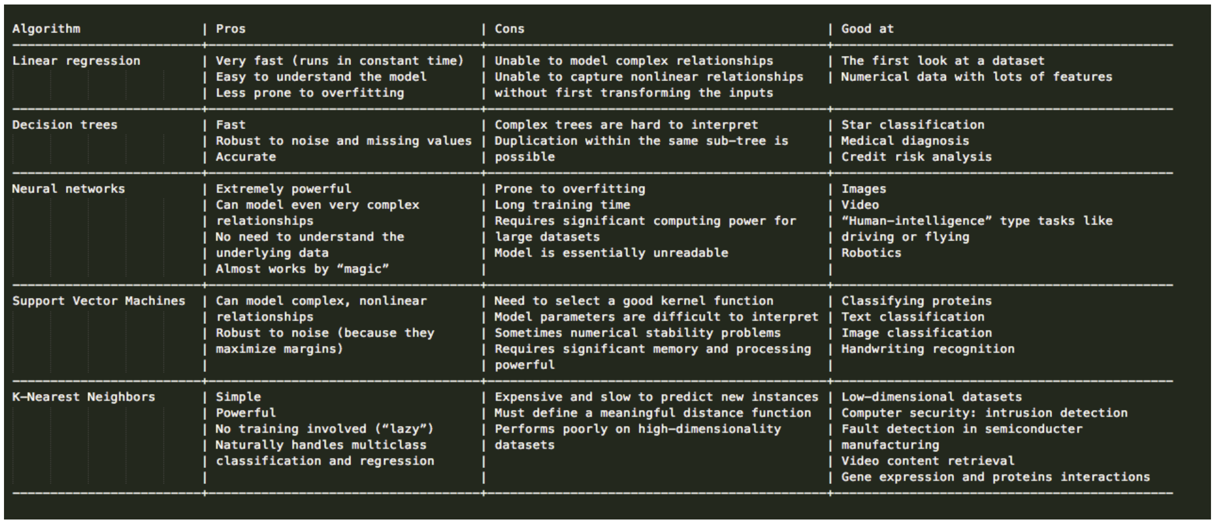
More Efficient Development lifecycle: Production systems may be easily cloned for use as development and test environments. Staging environments may be easily promoted to production.

Improved Testability: Never run out of hardware for testing. Inject and automate testing at every stage during the development process. You can spawn up an “instant test lab” with pre-configured environments only for the duration of testing phase.

Disaster Recovery and Business Continuity: The cloud provides a lower cost option for maintaining a fleet of DR servers and data storage. With the cloud, you can take advantage of geo-distribution and replicate the environment in other location within minutes.

“Overflow” the traffic to the cloud: With a few clicks and effective load balancing tactics, you can create a complete overflow-proof application by routing excess traffic to the cloud.

Machine Learning Briefs



```
Algorithm                | Pros                            | Cons                                         | Good at
-------------------------+---------------------------------+----------------------------------------------+---------------------------------------------
Linear regression        | Very fast (runs in constant time) | Unable to model complex relationships      | The first look at a dataset
                         | Easy to understand the model    | Unable to capture nonlinear relationships    | Numerical data with lots of features
                         | Less prone to overfitting       | without first transforming the inputs        
-------------------------+---------------------------------+----------------------------------------------+---------------------------------------------
Decision trees           | Fast                            | Complex trees are hard to interpret          | Star classification
                         | Robust to noise and missing values | Duplication within the same sub-tree is   | Medical diagnosis
                         | Accurate                        | possible                                     | Credit risk analysis
-------------------------+---------------------------------+----------------------------------------------+---------------------------------------------
Neural networks          | Extremely powerful              | Prone to overfitting                         | Images
                         | Can model even very complex     | Long training time                           | Video
                         | relationships                   | Requires significant computing power for     | “Human-intelligence” type tasks like
                         | No need to understand the       | large datasets                               | driving or flying
                         | underlying data                 | Model is essentially unreadable              | Robotics
                         | Almost works by “magic”         |                                              |
-------------------------+---------------------------------+----------------------------------------------+---------------------------------------------
Support Vector Machines  | Can model complex, nonlinear    | Need to select a good kernel function        | Classifying proteins
                         | relationships                   | Model parameters are difficult to interpret  | Text classification
                         | Robust to noise (because they   | Sometimes numerical stability problems       | Image classification
                         | maximize margins)               | Requires significant memory and processing   | Handwriting recognition
                         |                                 | powerful                                     |
-------------------------+---------------------------------+----------------------------------------------+---------------------------------------------
K-Nearest Neighbors      | Simple                          | Expensive and slow to predict new instances  | Low-dimensional datasets
                         | Powerful                        | Must define a meaningful distance function   | Computer security: intrusion detection
                         | No training involved (“lazy”)   | Performs poorly on high-dimensionality       | Fault detection in semiconducter
                         | Naturally handles multiclass    | datasets                                     | manufacturing
                         | classification and regression   |                                              | Video content retrieval
                         |                                 |                                              | Gene expression and proteins interactions
-------------------------+---------------------------------+----------------------------------------------+---------------------------------------------
```

DESIGN AND SCALABILITY [ARCHITECTURE DESIGN SKILLS]

```
HINT: WHAT WHOULD YOU DO AT WORK ? BE REAL: GIVE AWAY THE WEBAPP, DATASTORE AND GOOGLE CLOUD SKILLS.

- Know Twitter, Facebook, Google, Amazon design architectures and why's.

FOLLOW-THROUGH
1. SCOPE THE PROBLEM
    1.1 IDENTIFY ALL POSSIBLE FEATURES AND FUNCTIONALITIES OF THE SYSTEM
2. STRUCTURE THE ARCHITECTURE
    2.1 USE WHITEBOARD TO DRAW ALL YOUR PIECES: FRONT-END, ROUTES, HANDLERS, AND MODELS
3. IDENTIFY KEY ISSUES
    3.1 IS YOUR APP WIRTE-HEAVY OR READ-HEAVY ? WHAT DOES THIS MEANS?
    3.2 HAVE YOU DETECTED BOTTLENECKS?
    3.3 SHOULD WE DISTRIBUTE THE DATABASE?
4. RESOLVE THE ISSUES
    4.1 THIS IS A GREAT MOMENT TO ASK FOR FEEDBACK
```

MODELING

```
Explains the best practices from big, scalable, world class architectures.
```

Google (http://hypertable.com/documentation/architecture/)

```
Let be known that Google stands for a googol, which is the large number 10^100; that is, the digit 1 followed
by 100 zeroes. This was used as a metaphor for indexing the whole web using PageRank algorithm:

    PR(A) = (1-d) + d (PR(T1)/C(T1) + ... + PR(Tn)/C(Tn)) (http://infolab.stanford.edu/pub/papers/google.pdf)

Datacenters are filled up daily by www traffic, continous crawl and indexing (caffeine), latency-sensitive
apps (gmail) and user-user plus user-group sharings (docs). These data is handled by Google's distributed
systems infrastructure: Google File System (Hadoop), Google BigTable and MapReduce (Hadoop).

BigTable is widely used for web indexing, searches, millions of read/writes and several google products as it
serves as a distributed storage system for managing structured data. It distributes data as a sorted map,
which is physically sorted on a hashed row-key approach (e.g. com.yahoo.www).
```

Facebook

```
Facebook is LAMP: linux, apache, mySQL and PHP.

Hashed, horizontal sharding based upon Stanford and Carnegie universities. Use of memcache for "hot" sql
transfers across Cassandra, MySQL, Hadoop HBase (Log processing, Recommendation Systems, and Data Warehouse)
and HayStack (Photos).

Engineers had to work with two data stores and very different data models: a large cluster of MySQL servers
for storing data persistently in relational tables, and an equally large collection of memcache servers for
storing and serving flat key-value pairs derived (some indirectly) from the results of SQL queries.

For hardware details, look at: http://www.opencompute.org/
```

SCALABILITY & MEMORY LIMITS

STEP BY STEP APPROACH

```
    1. MAKE BELIEVE.
        Pretend that the data can all fit on one machine and there are no memory limitations.
        How would you solve the problem?
        This answer to this question will provide the general outline for your solution.
    2. GET REAL.
         How much data can you fit on one machine, and what problems will occur when you split (shard) the
data up?
         Common problems include figuring out how to logically divide the data up,
         and how one machine would identify where to look up a different piece of data.
    3. SOLVE PROBLEMS.
        Finally, think about how to solve the issues you identified in Step 2.
        Remember that the solution for each issue might be to actually remove the issue entirely,
        or it might be to simply mitigate the issue
```

HINTS FOR SHARDING

```
    * By Order of Appearance: advantage of never using more machines than are necessary. However, depending on
the problem and our data set, our lookup table may be more complex and potentially very large.

    * By Hash Value: : (1) pick some sort of key relating to the data, (2) hash the key, (3) mod the hash
value by the number of machines, and (4) store the data on the machine with that value. That is, the data is
stored on machine #[mod(hash(key), N)].

    * By Actual Value: we may be able to reduce system latency by using information about what the data
represents, for example geographic divisions.

    * Arbitrarily: Frequently, data just gets arbitrarily broken up and we implement a lookup table to
identify which machine holds a piece of data. While this does necessitate a potentially large lookup table, it
simplifies some aspects of system design and can enable us to do better load balancing.
```

SORTING AND SEARCHING

```
Understanding the common sorting and searching algorithms is incredibly valuable, as many of sorting and
searching problems are tweaks of the well-known algorithms. A good approach is therefore to run through the
different sorting algorithms and see if one applies particularly well.
```

SORTING

```
The most commonly used in interviews are:

* Mergesort: divide the n elements list into n lists of 1 element, keep on merging and sorting all sublists.
* Quicksort: pick a pivot and push left all smaller values, and right all greater. do it recursively with left
and right.
* Bucket sort: divide the n elements list into m buckets with n/m elements, sort each bucket and merge.

Python sort and sorted methods use mergesort algorithms, thus being quasilinear in complexity.
```

SEARCHING

```
Master the following algorithms:

* Binary search: given a sorted array, find an element dividing in halves recursively.
* Breadth first search (BFS): given a tree structure, start at the root and output nodes in an horizontal-
first approach.
* Depth first search (DFS): given a tree structure, start at the root and output nodes in a vertical-first
approach.
* Binary tree traversal: traverse a tree in BFS or DFS (in-order, pre-order, post-order)
```

UNIT TESTING

```
Unit testing is a software development process in which the smallest testable parts of an application, called
units, are individually and independently scrutinized for proper operation.

It implies units associated with control data, usage procedures, and operating procedures, to be tested to
determine whether they are fit for use.

In Python, there is the standard module unittest.py, i.e.:

    import unittest

    class TestUM(unittest.TestCase):

        def setUp(self):
            pass

        def test_numbers_3_4(self):
            self.assertEqual( 3*4, 12)

        def test_strings_a_3(self):
            self.assertEqual( 'a'*3, 'aaa')

        def test_split(self):
            s = 'hello world'
            self.assertEqual(s.split(), ['hello', 'world'])
            # check that s.split fails when the separator is not a string
            with self.assertRaises(TypeError):
                s.split(2)

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

GOOGLE DATASTORE AND APPENGINE SCALABILITY

```
As previously referred, Google's Datastore is a managed, NoSQL, schemaless database for storing non-relational
data. Cloud Datastore automatically scales as you need it and supports transactions as well as robust, SQL-
like queries. It runs in the available instance of a given application.

App Engine applications are powered by any number of dynamic instances at a given time, depending on the
volume of incoming requests. As requests for your application increase, so do the number of dynamic instances.

The App Engine scheduler decides whether to serve each new request with an existing instance (either one that
is idle or accepts concurrent requests), put the request in a pending request queue, or start a new instance
for that request. The decision takes into account the number of available instances, how quickly your
application has been serving requests (its latency), and how long it takes to spin up a new instance.

Additionally, datastore scales by sharding rows onto separate tablet servers, and these rows are
lexicographically ordered by key.
```

ALGORITHMS AND PROBLEM SOLVING [CODING SKILLS]

```
HINT: SHOW ANALYTICAL SKILLS, KEEP TRYING, COMMUNICATE YOUR THINKING, MAKE TRADEOFFS

- Master Big-O (Complexity), Trees and Graphs, MergeSort, BFS & DFS, Binary Search, Heaps, Recursion
- Python DS & Modules: List, Set, Dictionary, Itertools, Random, Collections, Heapq, Time; Functional
Programming

FOLLOW-THROUGH
1. LISTEN
    1.1 PATTERN MATCHING: WHAT PROBLEM IS THIS SIMILAR TO ?
    1.2 GET CLUES
2. EXAMPLE
3. BRUTE FORCE
4. OPTIMIZE
    4.1 (B)OTTLENECKS
    4.2 (U)NNECESSARY WORK
    4.3 (D)UPLICATE WORK
5. EXPLAIN|WALKTHROUGH
6. IMPLEMENT|BEAUTIFY CODE: METHODS AND CLASSES
    6.1 CORRECT CODE
    6.2 EFFICIENT: BIG-O PERFORMANCE, METHODS RE-USE
    6.3 SIMPLE AND MODULAR
    6.4 READABLE
    6.5 MAINTAINABLE
    6.6 BALANCED USE OF DATA STRUCTURES
7. TEST
    7.1 ANALYZE: LOOKS WEIRD ? ERROR HOT SPOTS?
    7.2 TEST CASES: SMALL, EDGE, BIGGER
```

FIVE ALGORITHM APPROACHES

1. EXAMPLIFY

```
    Write out specific examples until finding|deriving a rule of simplification or formula. Think of x
equations (examples) and y variables.
```

2. PATTERN MATCHING

```
    Think of familiarity and experience with past problems and modify solution in mind to the related problem.
Most of the times a clue is found while carefully listening the problem description. Example: Clock angle.
```

3. SIMPLIFY & GENERALIZE

```
    This is a multi-step approach useful when constraints are given. First we simplify a constraint such as
the amount of data or memory, and solve for this simpler problem. Once we had it, we adapt the earlier
solution for the more complex version. Example: Magazine words
```

4. BASE CASE AND BUILD

```
    This is a useful approach when you find a clue for recursion. Try first to solve for n=1, then n=1 and
n=2, and it's very possible for you to find a recursive approach when solved to n=4. Example: Permutations
```

5. DATA STRUCTURE BRAINSTORM

```
    It's hacky and works. Use different data structures as examples and try to apply each one. You'll be
surprised of how easy is to find the best data structure for your problem. Example: Median in growing array.
```

DATA STRUCTURES

- LIST

  Description:

  ```
    The list type is a container that holds a number of other objects, in a given order. The list type
  implements the sequence protocol, and also allows you to add and remove objects from the sequence.
  ```

  Implementation:

  ```
  l = [1,2,3]
  l = [1,'word',3]
  l[0] = 1
  ```

  Typical use:

```
  When you need a mixed collection of data all in one place.

  When the data needs to be ordered.

  When your data requires the ability to be changed or extended. Remember,lists are mutable.

  When you don't require data to be indexed by a custom value. Lists are numerically indexed and to
retrieve an element, you must know its numeric position in the list.

  When you need a stack or a queue. Lists can be easily manipulated by appending/removing elements from
the beginning/end of the list.

  When your data doesn't have to be unique. For that, you would use sets.

  When you need order as LIFO:  the stack implementation (append(), pop())

  When you need order as FIFO:  the deque implementation (append(), popleft())
```

Operations:

```
  Operation     | Example      | Complexity       | Notes
  --------------+--------------+---------------+-------------------------------
  Index         | l[i]         | O(1)          |
  Store         | l[i] = 0     | O(1)          |
  Length        | len(l)       | O(1)          |
  Append        | l.append(5)  | O(1)          |
  Pop           | l.pop()      | O(1)          | list as a stack (LIFO), same as l.pop(-1)
                | deque(l).popleft()           | list as a queue using collections.deque (FIFO)
  Clear         | l.clear()    | O(1)          | similar to l = []

  Slice         | l[a:b]       | O(b-a)        | l[1:5]:O(l)/l[:]:O(len(l)-0)=O(N)
  Extend        | l.extend(...)| O(len(...))   | depends only on len of extension
  Construction  | list(...)    | O(len(...))   | depends on length of argument

  check ==, !=  | l1 == l2     | O(N)          | O(len(string)) applies for strings
  Insert        | l[a:b] = ... | O(N)          |
                | l.insert(i,e)| O(N)          | insert element e at zero-based index i
  Delete        | del l[i]     | O(N)          |
  Remove        | l.remove(...)| O(N)          |
  Containment   | x in/not in l| O(N)          | searches list
  Copy          | l.copy()     | O(N)          | Same as l[:] which is O(N)
  Pop           | l.pop(0)     | O(N)          |
  Index of      | l.index(e)   | O(N)          | return the zero-index index of element e
  Find          | l.find(e)    | O(N)          | return the zero-index index of element e or -1
  Index of      | l.rindex(e)  | O(N)          | return the zero-index index of element e from right to
left
  Find          | l.rfind(e)   | O(N)          | return the zero-index index of element e or -1 from
right to left
  Count         | l.count(e)   | O(N)          | return the occurrence of element e in l

  Extreme value | min(l)/max(l)| O(N)          |
  Reverse       | l.reverse()  | O(N)          |
  Iteration     | for v in l:  | O(N)          |
                  l[::2]       | O(N)          | give all even indexes starting from 0
                  l[1::2]      | O(N)          | give all odd indexes starting from 1
                  l[::-1]      | O(N)          | reverses list

  Sort          | l.sort()     | O(N Log N)    | key/reverse change original l
                | sorted(l)    | O(N Log N)    | key/reverse doesn't change original l
  Multiply      | k*l          | O(k N)        | 5*l is O(N): len(l)*l is O(N**2)
```

- TUPLE

  Description:

  ```
  Tuples support all operations from lists that do not mutate the data structure
  (and with the same complexity classes).
  ```

  Implementation:

  ```
  >>> l = (1,2,3)
  >>> l = (1,'word',3)
  >>> l[0]
  1
  >>> l[0] = 1
  TypeError: 'tuple' object does not support item assignment
  ```

- SET

  Description:

  ```
    A set is an unordered collection with no duplicate elements. Basic uses include membership testing and
  eliminating duplicate entries. Set objects also support mathematical operations like union,
  intersection, difference, and symmetric difference. Sets have many more operations that are O(1)
  compared with lists and tuples.

    Not needing to keep values in a specific order (which lists/tuples require) allows for faster
  operations.

    Frozen sets support all operations that do not mutate the data structure.
  ```

  Typical use:

  ```
    When you need a unique set of data: Sets check the unicity of elements based on hashes.

    When your data constantly changes: Sets, just like lists, are mutable.

    When you need a collection that can be manipulated mathematically: with sets it's easy to do
  operations like difference, union, intersection, etc.

    When you don't need to store nested lists, sets, or dictionaries in a data structure: Sets don't
  support unhashable types.
  ```

  Implementation:

```
s = set([1,2,3])


EXAMPLES
>>> A = {1, 2, 3, 3}
>>> A
set([1, 2, 3])
>>> B = {3, 4, 5, 6, 7}
>>> B
set([3, 4, 5, 6, 7])
>>> A | B                           # also works like A.union(B)
set([1, 2, 3, 4, 5, 6, 7])
>>> A & B                           # also works like A.intersection(B)
set([3])
>>> A - B                           # also works like A.difference(B)
set([1, 2])
>>> B - A                           # also works like B.difference(A)
set([4, 5, 6, 7])
>>> A ^ B                           # also works like A.symmetric_difference(B)
set([1, 2, 4, 5, 6, 7])
>>> (A ^ B) == ((A - B) | (B - A))
True
>>> A.issubset(B)                   # test whether every element in s is in t
False
>>> A.issuperset(B)                 # test whether every element in t is in s
False
>>> some_list = ['a', 'b', 'c', 'b', 'd', 'm', 'n', 'n']
>>> duplicates = set([x for x in some_list if some_list.count(x) > 1])
>>> print(duplicates)
set(['b', 'n'])
```

Operations:

```
  Operation     | Example      | Complexity    | Notes
  --------------+--------------+---------------+-------------------------------
  Length        | len(s)       | O(1)          |
  Add           | s.add(e)     | O(1)          | adds element e as an insert(0,e)
  Containment   | x in/not in s| O(1)          | compare to list/tuple - O(N)
  Remove        | s.remove(5)  | O(1)          | compare to list/tuple - O(N)
  Discard       | s.discard(5) | O(1)          |
  Pop           | s.pop()      | O(1)          | compare to list - O(N), pops leftmost or FIFO
  Clear         | s.clear()    | O(1)          | similar to s = set()
  Update        | s.update(t)  | O(len(s)+len(t))| return set s with elements added from t

  Construction  | set(...)     | len(...)      |
  check ==, !=  | s != t       | O(min(len(s),lent(t))
  <=/<          | s <= t       | O(len(s1))    | issubset
  >=/>          | s >= t       | O(len(s2))    | issuperset s <= t == t >= s
  Union         | s | t        | O(len(s)+len(t)) | concatenation
  Intersection  | s & t        | O(min(len(s),lent(t))  | coincidence elements, using &= returns set s
keeping only elements also found in t
  Difference    | s - t        | O(len(t))     | s minus elements in t that are in s, using -= returns
set s after removing elements found in t
  Symmetric Diff| s ^ t        | O(len(s))     | concatenation without coincidence elements, using ^=
returns set s with elements from s or t but not both

  Iteration     | for v in s:  | O(N)          |
  Copy          | s.copy()     | O(N)          |
```

- DICTIONARY

  Description:

```
Dictionaries are sometimes found in other languages as “associative
memories” or “associative arrays”. Unlike sequences, which are indexed by a
range of numbers, dictionaries are indexed by keys, which can be any
immutable type; strings and numbers can always be keys. Most dict
operations are O(1).

It is best to think of a dictionary as an unordered set of key:value
pairs, with the requirement that the keys are unique (within one
dictionary). A pair of braces creates an empty dictionary: {}. Placing
a comma-separated list of key:value pairs within the braces adds initial
key:value pairs to the dictionary; this is also the way dictionaries are
written on output.

The main operations on a dictionary are storing a value with some key and
extracting the value given the key. It is also possible to delete a
key:value pair with del. If you store using a key that is already in use,
the old value associated with that key is forgotten. It is an error to
extract a value using a non-existent key.

The keys() method of a dictionary object returns a list of all the keys
used in the dictionary, in arbitrary order (if you want it sorted, just
apply the sorted() function to it). To check whether a single key is in the
dictionary, use the in keyword. The values() method returns a list of all
values used.
```

  Implementation:

```
d = {'api_key': 'mwkMqTWFnK0LzJHyfkeBGoS2hr2KG7WhHqSGX0SbDJ4',
        'container': 'CONTENTSHERE', 'channel': 'CHANNELHERE'}

d = dict([('as',1),('king',10)])
```

  Operations:

```
Operation      | Example       | Complexity     | Notes
--------------+--------------+----------------+-------------------------------
Index          | d[k]          | O(1)           | if k doesn't exists it throws KeyError
Store          | d[k] = v      | O(1)           |
Length         | len(d)        | O(1)           |
Delete         | del d[k]      | O(1)           |
get/setdefault| d.method      | O(1)           |
               | d.get(k)      | O(1)           | if k doesn't exists it throws None
Pop            | d.pop(k)      | O(1)           |
Pop item       | d.popitem()   | O(1)           | pops the first element as key,value tuple (FIFO)
Clear          | d.clear()     | O(1)           | similar to s = {} or = dict()
Views          | d.keys()      | O(1)           | list of keys
               | d.values()    | O(1)           | list of values
               | d.items()     | O(1)           | list of tuples as (key,value)

Construction   | dict(...)     | len(...)       |

Iteration      | for k in d:   | O(N)           | all forms: keys, values, items
                 for k,v in d.iteritems()       | for key, value pairs as k and v
```

Typical use:

```
When you need a logical association between a key:value pair.

When you need fast lookup for your data, based on a custom key.

When your data is being constantly modified. Remember, dictionaries are mutable.
```

- ORDEREDDICT

  Description

  ```
  An OrderedDict is a type of dictionary that remembers the order entries were added.
  ```

  Implementation:

  ```
  >>> from collections import OrderedDict
  >>> d = {'banana': 3, 'apple':4, 'pear': 1, 'orange': 2}
  >>> OrderedDict(sorted(d.items(), key=lambda t: t[0]))
  OrderedDict([('apple', 4), ('banana', 3), ('orange', 2), ('pear', 1)])
  >>> OrderedDict(sorted(d.items(), key=lambda t: t[1]))
  OrderedDict([('pear', 1), ('orange', 2), ('banana', 3), ('apple', 4)])
  ```

- DEFAULTDICT

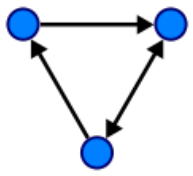
  Description

  ```
    A defaultdict is a type of dictionary that calls a factory function to supply missing values.
  For example:
    >>> s = 'missisipi'

    #regular dictionary
    >>> d = dict()
    >>> for k in s: d[k] += 1
    Traceback (most recent call last):
    File "<stdin>", line 1, in <module>
    KeyError: 'm'

    #defaultdict
    >>> dd = collections.defaultdict(int)
    >>> for k in s: dd[k] += 1
    >>> dd
    defaultdict(<type 'int'>, {'i': 4, 'p': 1, 's': 3, 'm': 1})
    >>>
  ```

  Implementation:

```
  >>> import collections
  >>> tree = lambda: collections.defaultdict(tree)
  >>> some_dict = tree()
  >>> some_dict['colours']['favourite'] = "yellow"    #if this wasn't a defaultdict it'll have
raised KeyError
  >>> import json
  >>> print(json.dumps(some_dict))
  {"colours": {"favourite": "yellow"}}

  >>> s = [('yellow', 1), ('blue', 2), ('yellow', 3), ('blue', 4), ('red', 1)]
  >>> d = defaultdict(list)
  >>> for k, v in s: d[k].append(v)
  >>> d.items()
  [('blue', [2, 4]), ('red', [1]), ('yellow', [1, 3])]

  >>> s = 'mississippi'
  >>> d = defaultdict(int)
  >>> for k in s: d[k] += 1
  >>> d.items()
  [('i', 4), ('p', 2), ('s', 4), ('m', 1)]
```

- GRAPH



Description:

```
  A data structure including cycles and paths in-between its nodes. You can say that a graph is a
tree where child nodes have multiple parents usually called predecessors, and parent-parent
relationships are possible (cycles).

  # Figure above as A, B and C nodes
  g = dict()
  g["a"]=["b"]
  g["b"]=["c"]
  g["c"]=["a","b"]
```

Implementation:

```
  """ A Python Class
  A simple Python graph class, demonstrating the essential
  facts and functionalities of graphs.
  """


  class Graph(object):

      def __init__(self, graph_dict={}):
          """ initializes a graph object """
          self.__graph_dict = graph_dict

      def vertices(self):
          """ returns the vertices of a graph """
          return list(self.__graph_dict.keys())
```

```
def edges(self):
    """ returns the edges of a graph """
    return self.__generate_edges()

def add_vertex(self, vertex):
    """ If the vertex "vertex" is not in
        self.__graph_dict, a key "vertex" with an empty
        list as a value is added to the dictionary.
        Otherwise nothing has to be done.
    """
    if vertex not in self.__graph_dict:
        self.__graph_dict[vertex] = []

def add_edge(self, edge):
    """ assumes that edge is of type set, tuple or list;
        between two vertices can be multiple edges!
    """
    edge = set(edge)
    (vertex1, vertex2) = tuple(edge)
    if vertex1 in self.__graph_dict:
        self.__graph_dict[vertex1].append(vertex2)
    else:
        self.__graph_dict[vertex1] = [vertex2]

def __generate_edges(self):
    """ A static method generating the edges of the
        graph "graph". Edges are represented as sets
        with one (a loop back to the vertex) or two
        vertices
    """
    edges = []
    for vertex in self.__graph_dict:
        for neighbour in self.__graph_dict[vertex]:
            if {neighbour, vertex} not in edges:
                edges.append({vertex, neighbour})
    return edges

def __str__(self):
    res = "vertices: "
    for k in self.__graph_dict:
        res += str(k) + " "
    res += "\nedges: "
    for edge in self.__generate_edges():
        res += str(edge) + " "
    return res

def find_path(self, start_vertex, end_vertex, path=[]):
    """ find a path from start_vertex to end_vertex
        in graph """
    graph = self.__graph_dict
    path = path + [start_vertex]
    if start_vertex == end_vertex:
        return path
    if start_vertex not in graph:
        return None
    for vertex in graph[start_vertex]:
        if vertex not in path:
            extended_path = self.find_path(vertex,
                                           end_vertex,
                                           path)
            if extended_path:
                return extended_path
    return None
```

```
def find_all_paths(self, start_vertex, end_vertex, path=[]):
    """ find all paths from start_vertex to
        end_vertex in graph """
    graph = self.__graph_dict
    path = path + [start_vertex]
    if start_vertex == end_vertex:
        return [path]
    if start_vertex not in graph:
        return []
    paths = []
    for vertex in graph[start_vertex]:
        if vertex not in path:
            extended_paths = self.find_all_paths(vertex,
                                                 end_vertex,
                                                 path)
            for p in extended_paths:
                paths.append(p)
    return paths

def vertex_degree(self, vertex):
    """ The degree of a vertex is the number of edges connecting
        it, i.e. the number of adjacent vertices. Loops are counted
        double, i.e. every occurence of vertex in the list
        of adjacent vertices. """
    adj_vertices =  self.__graph_dict[vertex]
    degree = len(adj_vertices) + adj_vertices.count(vertex)
    return degree

def find_isolated_vertices(self):
    """ returns a list of isolated vertices. """
    graph = self.__graph_dict
    isolated = []
    for vertex in graph:
        print(isolated, vertex)
        if not graph[vertex]:
            isolated += [vertex]
    return isolated

def delta(self):
    """ the minimum degree of the vertices """
    min = 100000000
    for vertex in self.__graph_dict:
        vertex_degree = self.vertex_degree(vertex)
        if vertex_degree < min:
            min = vertex_degree
    return min

def Delta(self):
    """ the maximum degree of the vertices """
    max = 0
    for vertex in self.__graph_dict:
        vertex_degree = self.vertex_degree(vertex)
        if vertex_degree > max:
            max = vertex_degree
    return max

def degree_sequence(self):
    """ calculates the degree sequence """
    seq = []
    for vertex in self.__graph_dict:
        seq.append(self.vertex_degree(vertex))
    seq.sort(reverse=True)
    return tuple(seq)
    def density(self):
        """ method to calculate the density of a graph """
        g = self.__graph_dict
        V = len(g.keys())
        E = len(self.edges())
        return 2.0 * E / (V *(V - 1))

if __name__ == "__main__":

    g = { "a" : ["d"], "b" : ["c"], "c" : ["b", "c", "d", "e"], "d" : ["a", "c"], "e" :
["c"],"f" : []}

    graph = Graph(g)

    # or maybe
    z = dict()
    z["a"]=["d"]
    z["c"]=["b","c","d","e"]
    z["b"]=["c"]
    z["e"]=["c"]
    z["d"]=["a","c"]
    z["f"]=[]

    graph = Graph(z)
```

Operations:

```
graph.vertices()                    #O(|V|)
graph.edges()                       #O(|E|)
graph.add_vertex("z")               #O(1)
graph.add_edge({"a","z"})           #O(1)
graph.density()
graph.find_all_paths("a", "e")
```

Typical use:

```
* Modeling a computer network

* Modeling a city map

* Social networks

* State machines
```

Traversal: DFS & BFS

Breadth first and depth first are useful graph traversal and searching algorithms.

DFS is typically the easiest if we want to visit every node in the graph, or at least visit every node until we find whatever we're looking for. However, if we have a very large tree and want to be prepared to quit when we get too far from the original node, DFS can be problematic; we might search thousands of ancestors of the node, but never even search all of the node's children. In these cases, BFS is typically preferred.

DFS PSEUDOCODE:
    Visit all successors first, usually through recursion. Pseudocode:

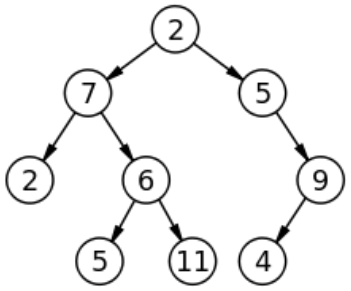
```
def DFS(node):
    for child in node:
        DFS(child)
    print ("visited %s" % node)
```

BFS PSEUDOCODE:
    Visit nearest nodes, usually through queues. Pseudocode:

```
def BFS(node):
    queue.append(node)
    while queue not empty
        v = queue.popleft()
        print ("visited %s" % v)
        for child in v:
            queue.append(child)
```

Note: the given python class for graph implementation has its own search methods.

- TREES



Description:

```
  A tree is essentially a restricted form of a graph where there are no cycles, no directions, and
there's always a parent-child (root-leaf) relationship between nodes.

  Binary Tree vs. Binary Search Tree (BST, searches O(log2(n)))
  When given a binary tree question, many candidates assume that the interviewer means binary
search tree. Be sure to ask whether or not the tree is a binary search tree. A binary search tree
imposes the condition that, for all nodes, the left children are less than or equal to the current
node, which is less than all the right nodes.

  Balanced (h = log2(n)) vs. Unbalanced
  A balanced tree implies that for each node its subtrees contain nearly equal number of nodes.
While many trees are balanced, not all are. Ask your interviewer for clarification on this issue.
If the tree is unbalanced, you should describe your algorithm in terms of both the average and the
worst case time. Note that there are multiple ways to balance a tree, and balancing a tree implies
only that the depth of subtrees will not vary by more than a certain amount. It does not mean that
the left and right subtrees are exactly the same size.

  Full and Complete
  Full and complete trees are trees in which all leaves are at the bottom of the tree, and all
non-leaf nodes have exactly two children. Note that full and complete trees are extremely rare, as
a tree must have exactly 2n - 1 nodes to meet this condition

  Binary Tree Traversal
  Prior to your interview, you should be comfortable implementing in-order, post-order, and pre-
order traversal. The most common of these, in-order traversal, works by visiting the left side,
then the current node, then the right.
```

BINARY TREE

Description:

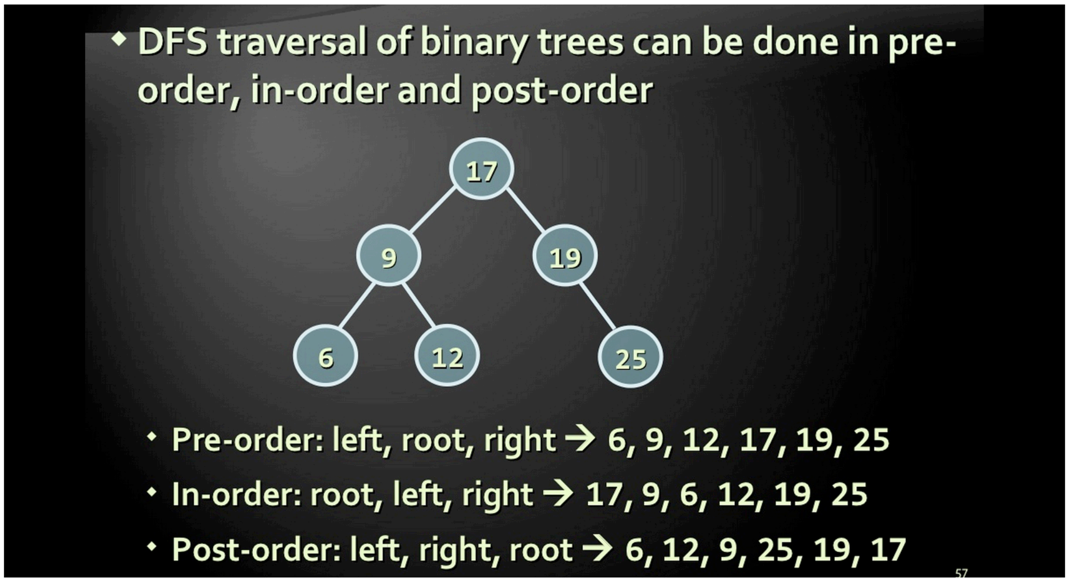
```
  This is the most widespread form of a tree-like data structure, each node has at most 2
children.
```

Implementation:

```
    class BinaryTree():

        def __init__(self,rootid):
            self.left = None
            self.right = None
            self.rootid = rootid

        def getLeftChild(self):
            return self.left
        def getRightChild(self):
            return self.right
        def setNodeValue(self,value):
            self.rootid = value
        def getNodeValue(self):
            return self.rootid
        def insertRight(self,newNode):
            if self.right == None:
                self.right = BinaryTree(newNode)
            else:
                tree = BinaryTree(newNode)
                tree.right = self.right
                self.right = tree
        def insertLeft(self,newNode):
            if self.left == None:
                self.left = BinaryTree(newNode)
            else:
                tree = BinaryTree(newNode)
                self.left = tree
                tree.left = self.left
```

Traversal DFS:

```
in-order:
Means to visit left - root - right.

pre-order:

Means to visit root - left - right.

post-order:

Means to visit left - right - root.
```



- DFS traversal of binary trees can be done in pre-order, in-order and post-order

17
9
19
6
12
25

- Pre-order: left, root, right → 6, 9, 12, 17, 19, 25
- In-order: root, left, right → 17, 9, 6, 12, 19, 25
- Post-order: left, right, root → 6, 12, 9, 25, 19, 17

57

Operations:

```
Balanced tree:

add     #O(log(n))
search  #O(log(n))
delete  #O(log(n))
```

Typical use:

```
* Object hierarchies

* Filesystem traversal, e.g. using recursive DFS:

    def disk_usage(path):
        """Return the number of bytes used by a file/folder and any descendents."""
        total = os.path.getsize(path) # account for direct usage
        if os.path.isdir(path): # if this is a directory,
            for filename in os.listdir(path): # then for each child:
                childpath = os.path.join(path, filename) # compose full path to child
                total += disk_usage(childpath)

        print "%s bytes or %s Mb or %s Gb -- for path >>  %s" % (format(total,",d"), 
format(total//1000000,",d"), format(total/1000000000,",d"), path) # descriptive output (optional)
        return total # return the grand total
```

TRIE

Description:

```
  The term trie comes from retrieval. A trie is a variant of an n-ary tree in which characters are
stored at each node. Each path down the tree may represent a word. Using trie, search complexities
can be brought to optimal limit (key length). If we store keys in binary search tree, a well
balanced BST will need time proportional to M * log N, where M is maximum string length and N is
number of keys in tree. Using trie, we can search the key in O(M) time. However the penalty is on
trie storage requirements. Insert and search costs O(key_length), however the memory requirements
of trie is O(ALPHABET_SIZE * key_length * N) where N is number of keys in trie. T
```

Implementation:

```
def make_trie(*args):
    """
    Make a trie by given words.
    """
    trie = {}

    for word in args:
        if type(word) != str:
            raise TypeError("Trie only works on str!")
        temp_trie = trie
        for letter in word:
            temp_trie = temp_trie.setdefault(letter, {})
        temp_trie = temp_trie.setdefault('_end_', '_end_')

    return trie

if __name__ == '__main__':
    trie = make_trie('hello', 'abc', 'baz', 'bar', 'barz')
    print trie
```

Operations:

```python
def in_trie(trie, word):
    """
    Detect if word in trie.
    """
    if type(word) != str:
        raise TypeError("Trie only works on str!")

    temp_trie = trie
    for letter in word:
        if letter not in temp_trie:
            return False
        temp_trie = temp_trie[letter]
    return True


def remove_from_trie(trie, word, depth):
    """
    Remove certain word from trie.
    """
    if word and word[depth] not in trie:
        return False

    if len(word) == depth + 1:
        del trie[word[depth]]
        if not trie:  # Node becomes a leaf, indicate its parent to delete it.
            return True
        return False
    else:
        temp_trie = trie

        # Recursively climb up to delete.
        if remove_from_trie(temp_trie[word[depth]], word, depth + 1):
            if temp_trie:
                del temp_trie[word[depth]]
            return not temp_trie
    return False
```

Typical use:

```
* Store associative array where the keys are usually strings
```

PYTHON TRICKS & BUILT-INS

args and kwargs

```
*args : additional arguments

>>> def test_var_args(f_arg, *argv):
....    print "first normal arg:", f_arg
....    for arg in argv:
....        print "another arg through *argv :", arg

>>> test_var_args('yasoob','python','eggs','test')

>>> first normal arg: yasoob
>>> another arg through *argv : python
>>> another arg through *argv : eggs
>>> another arg through *argv : test

*kwargs : additional keyed arguments

>>> def greet_me(**kwargs):
....    if kwargs is not None:
....        for key, value in kwargs.iteritems():
....            print "%s == %s" %(key,value)

>>> greet_me(name="yasoob")
name == yasoob
```

Slicing

```
>>> a = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
>>> a[2:8]
[2, 3, 4, 5, 6, 7]

>>> a = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
>>> a[-4:-2]
[7, 8]

>>> a = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
>>> a[::2]
[0, 2, 4, 6, 8, 10]
>>> a[2:8:2]
[2, 4, 6]

>>> a = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10]
>>> a[::-1]
[10, 9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
```

Enumerate

```
Similar to a dictionary, enumerate returns numeric-keyed value pairs as a list of tuples.

>>> seasons = ['Spring', 'Summer', 'Fall', 'Winter']
>>> list(enumerate(seasons))
[(0, 'Spring'), (1, 'Summer'), (2, 'Fall'), (3, 'Winter')]
```

Flattening

```
>>> a = [1, 2, [3, 4], [[5, 6], [7, 8]]]
>>> flatten = lambda x: [y for l in x for y in flatten(l)] if type(x) is list else [x]
>>> flatten(a)
[1, 2, 3, 4, 5, 6, 7, 8]
```

Zip

```
This function returns a list of tuples, where the i-th tuple contains the i-th element from each of the
argument sequences or iterables. The returned list is truncated in length to the length of the shortest
argument sequence.

>>> a = [1, 2, 3]
>>> b = ['a', 'b', 'c']
>>> z = zip(a, b)
>>> z
[(1, 'a'), (2, 'b'), (3, 'c')]
>>> zip(*z)
[(1, 2, 3), ('a', 'b', 'c')]

>>> x= [1,2,3]
>>> y=[4,5,6]
>>> [a+b for a,b in zip(x,y)]
[5, 7, 9]

#grouping
>>> a = [1, 2, 3, 4, 5, 6]
>>> group_adjacent = lambda a, k: zip(*([iter(a)] * k))
>>> group_adjacent(a, 3)
[(1, 2, 3), (4, 5, 6)]

#n grams
>>> from itertools import islice
>>> def n_grams(a, n):
...     z = (islice(a, i, None) for i in range(n))
...     return zip(*z)
...
>>> a = [1, 2, 3, 4, 5, 6]
>>> n_grams(a, 3)
[(1, 2, 3), (2, 3, 4), (3, 4, 5), (4, 5, 6)]

#inverting dict
>>> m = {'a': 1, 'b': 2, 'c': 3, 'd': 4}
>>> dict(zip(m.values(), m.keys()))
{1: 'a', 2: 'b', 3: 'c', 4: 'd'}
```

Filter

```
>>> def f(x): return x % 3 == 0 or x % 5 == 0
>>> filter(f, range(2, 25))
[3, 5, 6, 9, 10, 12, 15, 18, 20, 21, 24]
>>> number_list = range(-5, 5)
>>> less_than_zero = list(filter(lambda x: x < 0, number_list))
>>> less_than_zero
[-5, -4, -3, -2, -1]
```

Map

```
>>> def cube(x): return x*x*x
>>> map(cube, range(1, 11))
[1, 8, 27, 64, 125, 216, 343, 512, 729, 1000]
>>> items = [1, 2, 3, 4, 5]
>>> squared = map(lambda x: x**2, items)
[1, 4, 9, 16, 25]
# list comprehension approach
```

Reduce

```
>>> def add(x,y): return x+y
>>> reduce(add, range(1, 11))
55
```

List comprehension

```
Matrix of Zeros (WxL):
>>> zero_grid = [ [0] * W for j in range(L) ]

Filtering:
>>> [x for x in range(2,25) if x % 3 == 0 or x % 5 == 0]
[3, 5, 6, 9, 10, 12, 15, 18, 20, 21, 24]

Mapping:
>>> [x*x*x for x in range(1,11)]
[1, 8, 27, 64, 125, 216, 343, 512, 729, 1000]
```

Dictionary comprehension

```
>>> m = {x: 'A' + str(x) for x in range(10)}
>>> m
{0: 'A0', 1: 'A1', 2: 'A2', 3: 'A3', 4: 'A4', 5: 'A5', 6: 'A6', 7: 'A7', 8: 'A8', 9: 'A9'}
>>> {v: k for k, v in m.items()}
{'A1': 1, 'A0': 0, 'A3': 3, 'A2': 2, 'A5': 5, 'A4': 4, 'A7': 7, 'A6': 6, 'A9': 9, 'A8': 8}
```

Exceptions

```
Exception handling is an art which once you master grants you immense powers.

try:
    file = open('test.txt', 'rb')
except Exception as e:
    print('An error occurred: %s' % (format(e.args[-1])))
finally:
    print("This would be printed even if no exception occurs!")
```

Lambdas

```
Lambdas are one line functions. They are also known as anonymous functions in some other languages. You might
want to use lambdas when you don’t want to use a function twice in a program. They are just like normal
functions and even behave like them.

>>> add = lambda x, y: x + y
>>> print(add(3, 5))
8

>>> a = [(1, 2), (4, 1), (9, 10), (13, -3)]
>>> a.sort(key=lambda x: x[1])
>>> print(a)
# Output: [(13, -3), (4, 1), (1, 2), (9, 10)]
```

DIVMOD

```
>>> divmod(5,2)
(2, 1)
>>> 5 % 2
1
```

Sorting

```
>>> sorted([5, 2, 3, 1, 4])
[1, 2, 3, 4, 5]
>>> sorted([5, 2, 3, 1, 4], reverse=True)
[5, 4, 3, 2, 1]
>>> sorted("This is a test string from Andrew".split(), key=str.lower)
['a', 'Andrew', 'from', 'is', 'string', 'test', 'This']
>>> student_tuples = [
    ('john', 'A', 15),
    ('jane', 'B', 12),
    ('dave', 'B', 10),
]
>>> sorted(student_tuples, key=lambda student: student[2])   # sort by age
[('dave', 'B', 10), ('jane', 'B', 12), ('john', 'A', 15)]
# same works for named objects:
>>> class Student:
    def __init__(self, name, grade, age):
        self.name = name
        self.grade = grade
        self.age = age
    def __repr__(self):
        return repr((self.name, self.grade, self.age))
>>> student_objects = [
    Student('john', 'A', 15),
    Student('jane', 'B', 12),
    Student('dave', 'B', 10),
]
>>> sorted(student_objects, key=lambda student: student.age)   # sort by age
[('dave', 'B', 10), ('jane', 'B', 12), ('john', 'A', 15)]
```

Complete list of built-ins

```
abs()   divmod()    input() open()  staticmethod(
all()   enumerate() int()   ord()   str()
any()   eval()  isinstance()    pow()   sum()
basestring()    execfile()  issubclass()    print() super(
bin()   file()  iter()  property()  tuple()
bool()  filter()    len()   range() type()
bytearray() float() list()  raw_input() unichr()
callable()  format()    locals()    reduce()    unicode()
chr()   frozenset() long()  reload()    vars()
classmethod()   getattr()   map()   repr()  xrange()
cmp()   globals()   max()   reversed()  zip()
compile()   hasattr()   memoryview()    round() __import__()
complex()   hash()  min()   set()
delattr()   help()  next()  setattr()
dict()  hex()   object()    slice()
dir()   id()    oct()   sorted()
```

PYTHON USEFUL STANDARD IMPORTS

Itertools *(python module)*

```
itertools (https://docs.python.org/2.7/library/itertools.html)

        This module implements a number of iterator building blocks inspired by constructs from APL, Haskell,
and SML. Each has been recast in a form suitable for Python.

        itertools.product('ABCD', repeat=2)                     AA AB AC AD BA BB BC BD CA CB CC CD DA DB DC
DD
        itertools.permutations('ABCD', 2)                       AB AC AD BA BC BD CA CB CD DA DB DC
        itertools.combinations('ABCD', 2)                       AB AC AD BC BD CD
        itertools.combinations_with_replacement('ABCD', 2)      AA AB AC AD BB BC BD CC CD DD
        itertools.product([0,1],repeat = 2)                     00 01 10 11

EXAMPLE FOR COUNTING ALL PERMUTATIONS IN A GIVEN STRING
>>> import itertools
>>> z = []
>>> for i in itertools.permutations('abc',3): z.append(i)
>>> z
[('a', 'b', 'c'), ('a', 'c', 'b'), ('b', 'a', 'c'), ('b', 'c', 'a'), ('c', 'a', 'b'), ('c', 'b', 'a')]
>>> z_list = [a+b+c for a,b,c in z]
>>> z_list
['abc', 'acb', 'bac', 'bca', 'cab', 'cba']
>>> s = "abcabcabc"
>>> counter = 0
>>> for i in z_list: counter += s.count(i)
>>> counter
7
```

Collections *(python module)*

```
collections (https://docs.python.org/2.7/library/collections.html)

        This module implements specialized container datatypes providing alternatives to Python’s general
purpose built-in containers, dict, list, set, and tuple.

        collections.Counter         dict subclass for counting hashable objects
        collections.deque           list-like container with fast appends and pops on either end
        collections.OrderedDict     dict subclass that remembers the order entries were added

        collections.defaultdict     dict subclass useful for trees (calls a factory function)

EXAMPLE COUNTER
>>> Counter('abracadabra').most_common(3)
[('a', 5), ('r', 2), ('b', 2)]
>>> import re
>>> words = re.findall(r'\w+', open('hamlet.txt').read().lower())
>>> Counter(words).most_common(4)
[('the', 1143), ('and', 966), ('to', 762), ('of', 669)]

EXAMPLE DEQUE
>>> queue = deque(["Eric", "John", "Michael"])
>>> queue.append("Terry")           # Terry arrives
>>> queue.append("Graham")          # Graham arrives
>>> queue.popleft()                 # The first to arrive now leaves
'Eric'
>>> queue.popleft()                 # The second to arrive now leaves
'John'
>>> queue                           # Remaining queue in order of arrival
deque(['Michael', 'Terry', 'Graham'])
>>> Q = deque([5, 2, 1, 3])
>>> Q.rotate(3)
deque([2, 1, 3, 5])
>>> def moving_average(iterable, n=3):
        # moving_average([40, 30, 50, 46, 39, 44]) --> 40.0 42.0 45.0 43.0
        # http://en.wikipedia.org/wiki/Moving_average
        it = iter(iterable)
        d = deque(itertools.islice(it, n-1))
        d.appendleft(0)
        s = sum(d)
        for elem in it:
            s += elem - d.popleft()
            d.append(elem)
            yield s / float(n)

EXAMPLE ORDEREDDICT
>>> d = {'banana': 3, 'apple':4, 'pear': 1, 'orange': 2}
>>> OrderedDict(sorted(d.items(), key=lambda t: t[0]))
OrderedDict([('apple', 4), ('banana', 3), ('orange', 2), ('pear', 1)])
>>> OrderedDict(sorted(d.items(), key=lambda t: t[1]))
OrderedDict([('pear', 1), ('orange', 2), ('banana', 3), ('apple', 4)])

EXAMPLE DEFAULTDICT
>>> import collections
>>> tree = lambda: collections.defaultdict(tree)
>>> some_dict = tree()
>>> some_dict['colours']['favourite'] = "yellow"    #if this wasn't a defaultdict it'll have raised KeyError
>>> import json
>>> print(json.dumps(some_dict))
{"colours": {"favourite": "yellow"}}
```

Random *(python module)*

```
random (https://docs.python.org/2.7/library/random.html)

    This module implements pseudo-random number generators for various distributions.
    For integers, uniform selection from a range. For sequences, uniform selection of a random element, a
function
    to generate a random permutation of a list in-place, and a function for random sampling without
replacement.

EXAMPLE

>>> random.random()        # Random float x, 0.0 <= x < 1.0
0.37444887175646646
>>> random.uniform(1, 10)  # Random float x, 1.0 <= x < 10.0
1.1800146073117523
>>> random.randint(1, 10)  # Integer from 1 to 10, endpoints included
7
>>> random.randrange(0, 101, 2)  # Even integer from 0 to 100
26
>>> random.choice('abcdefghij')  # Choose a random element
'c'
>>> items = [1, 2, 3, 4, 5, 6, 7]
>>> random.shuffle(items)
>>> items
[7, 3, 2, 5, 6, 4, 1]
>>> random.sample([1, 2, 3, 4, 5],  3)  # Choose 3 elements
[4, 1, 5]
```

Heapq *(python module)*

```
heapq (https://docs.python.org/2.7/library/heapq.html)

    This module provides an implementation of the heap queue algorithm, also known as the priority queue
algorithm.
    Heaps are binary trees for which every parent node has a value less than or equal to any of its children.
This
    implementation uses arrays for which heap[k] <= heap[2*k+1] and heap[k] <= heap[2*k+2] for all k, counting
    elements from zero. For the sake of comparison, non-existing elements are considered to be infinite. The
    interesting property of a heap is that its smallest element is always the root, heap[0].

EXAMPLE

>>> from heapq import heappush, heappop
>>> def heapsort(iterable):
...     h = []
...     for value in iterable:
...         heappush(h, value)
...     return [heappop(h) for i in range(len(h)]
>>> heapsort([1, 3, 5, 7, 9, 2, 4, 6, 8, 0])
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Time *(python module)*

```
time (https://docs.python.org/2.7/library/time.html)

    This module is useful for testing complexity and computational cost in terms of time.

EXAMPLE

>>> from time import time
>>> def InsertionSort(A):
...     start_time = time() # record the starting time
...     for j in range(1, len(A)):
...         key = A[j]
...         i = j - 1
...         while (i >=0) and (A[i] > key):
...             A[i+1] = A[i]
...             i = i - 1
...         A[i+1] = key
...     end_time = time() # record the ending time
...     elapsed = end_time - start_time
...     print "Elapsed time (ms): %s" % (elapsed)
...     return A
```

Math *(python module)*

```
math (https://docs.python.org/2/library/math.html)

    This module is always available. It provides access to the mathematical functions defined by the C
standard.

EXAMPLE

>>> import math
>>> math.pi
3.141592653589793
>>> math.sin(math.pi/2)
1.0
>>> math.log(4,2)
2.0
>>> math.factorial(4)
24
```

re *(python module)*

```
re (https://docs.python.org/2/howto/regex.html)

    This module provides Perl-style regular expression patterns.

>>> import re
>>> words = re.findall(r'\w+', open('hamlet.txt').read().lower())

>>> p = re.compile('\d+')
>>> p.findall('12 drummers drumming, 11 pipers piping, 10 lords a-leaping')
['12', '11', '10']

>>> p = re.compile(r'(\b\w+)\s+\1')
>>> p.search('Paris in the the spring').group()
'the the'

>>> p = re.compile( '(blue|white|red)')
>>> p.sub( 'colour', 'blue socks and red shoes')
'colour socks and colour shoes'
```

ALGORITHMS

SORT

```
Is worth to refer that python exercises of sorting algorithms provide the following leading results:
    1) Numpy
    2) Native
    3) Quicksort list comprehension
    4) Mergesort
```

- MERGE-SORT

```
  Merge sort is a recursive algorithm that continually splits a list in half. If the list is empty or
has one item, it is sorted by definition (the base case). If the list has more than one item, we split
the list and recursively invoke a merge sort on both halves.

  def mergeSort(alist):
      print("Splitting ",alist)
      if len(alist)>1:
          mid = len(alist)//2
          lefthalf = alist[:mid]
          righthalf = alist[mid:]

          mergeSort(lefthalf)
          mergeSort(righthalf)

          i=0
          j=0
          k=0
          while i < len(lefthalf) and j < len(righthalf):
              if lefthalf[i] < righthalf[j]:
                  alist[k]=lefthalf[i]
                  i=i+1
              else:
                  alist[k]=righthalf[j]
                  j=j+1
              k=k+1

          while i < len(lefthalf):
              alist[k]=lefthalf[i]
              i=i+1
              k=k+1

          while j < len(righthalf):
              alist[k]=righthalf[j]
              j=j+1
              k=k+1
      print("Merging ",alist)

  alist = [54,26,93,17,77,31,44,55,20]
  mergeSort(alist)
  print(alist)
```

- QUICK-SORT

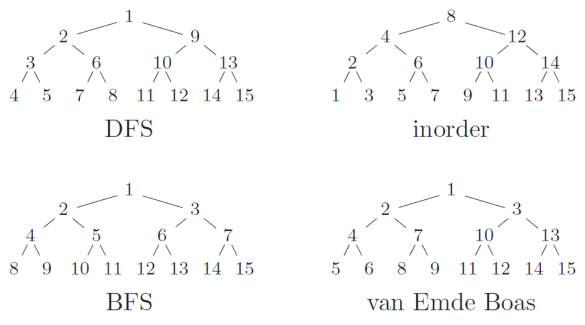
```
  Quick sort is a recursive algorithm that continually splits a list according to a pivotValue. If the
list is empty or has one item, it is sorted by definition (the base case). If the list has more than one
item, we split the list with all values below pivot in one side and all values above pivot on another
side, and recursively invoke a quick sort on both side.

  Python methods work faster in Big-O, but an implementation of quick sort can be:

  def quickSort(list):
      """Quicksort using list comprehensions"""
      if list == []:
          return []
      else:
          pivot = list[0]
          lesser = quickSort([x for x in list[1:] if x < pivot])
          greater = quickSort([x for x in list[1:] if x >= pivot])
          return lesser + [pivot] + greater

  alist = [54,26,93,17,77,31,44,55,20]
  alist = quickSort(alist)
  print(alist)
```

SEARCH

- BINARY SEARCH

```
  After sorting an array, binary search is a useful algorithm based on divide and conquer.

          def binary_search(S, target):
              """Return True if target found, else False."""
              start = 0
              stop = len(S)
              if start >= stop: # zero elements in slice
                  return False
              else: # two or more elements in slice
                  mid = (start + stop) // 2
              if target == S[mid]:
                  return True
              elif target > S[mid]:
                  return binary_search(S[mid+1:], target)
              else:
                  return binary_search(S[:mid-1], target)
```

- DFS & BFS



THE OFFER

```
HINT: HANDLE THE POST-INTERVIEW STRESS
- Think of deadlines and extensions if necessary
- Handle with care if you think to decline, keep a line of communication open
```

AND YOUR REAL SALARY IS...

- OFFER SALARY

  This is your periodical income.
- SIGNING BONUS, RELOCATION AND ONE-TIME PERKS

  When comparing offers, it's wise to amortize this cash over three years (or however long you expect to stay).
- COST OF LIVING DIFFERENCE

  Silicon Valley, for example, is about 20 to 30% more expensive than Seattle.
- ANNUAL BONUS

  This ranges from anywhere from 3% to 30%.
- STOCK OPTIONS AND GRANTS

  Equity compensation can form another big part. Amortize this cash over three years and lump that value into salary.
- PROMOTION PLAN

  This is not money in your pocket, but it can or can't be in your near future in the company.
- HAPPINESS FACTOR

  Think of the product, the culture, working hours, and if possible meet your Manager and Teammates.