Name:

Instructions

1. Write your name at the top of the *first* page and your initials at the bottom of *every* page.
2. When you are done, return the exam with *all* the pages, arranged in *ascending* order. Do *not* staple the exam.
3. This is a closed-book exam. No form of communication is permitted (eg, talking, texting, etc.), except with the course staff.
4. No electronic devices are permitted.
5. There are 25 multiple-choice questions in this exam, each worth 3 points.
6. The answer to each question must be marked *with a pencil* as shown in the following example. It will be considered incorrect otherwise.

   Example. What is Albert Einstein's miracle year?

   (A) 1879
   (B) 1900
   (C) 1905
   (D) 1917
   (E) 1955
7. You may use the blank spaces for any scratch work.
8. Discussing the exam contents with anyone who has not taken the exam is a violation of the academic honesty code.

Problem 1. If `s` is a string object, `s.replace(u, v)` returns a string with all occurrences of `u` in `s` replaced with `v`, and `s.find(u)` returns the lowest index in `s` where `u` is found, or `-1`. For example, `'abba'.replace('b', 'a')` returns `'aaaa'`, `'abba'.find('b')` returns `1`, and `'abba'.find('z')` returns `-1`. Consider the following functions:

```
def f(x, y, z):
    return x.replace(y, z)

def g(x, y='abcdr'):
    z = 0
    for v in y:
        z += x.find(v)
    return z
```

a. What does `f('abracadabra', 'abcdr'[1], 'vwxyz'[4])` return?

(A) `'ayracadayra'`
(B) `'zbrzczdzbrz'`
(C) `'azracadabra'`
(D) `'abwacadabwa'`
(E) `'azracadazra'`

b. What does `g('abracadabra')` return?

(A) 15

(B) 11

(C) 13

(D) 14

(E) 12

c. What does `g('abracadabra', 'parrot'[2:4])` return?

(A) 4

(B) 2

(C) 1

(D) 3

(E) 0

d. What does `g(f('abracadabra', 'abcdr'[3], 'vwxyz'[4]))` return?

(A) 7

(B) 1

(C) 6

(D) 2

(E) 4

Problem 2. Consider the following functions:

```
def f(x):
    st = SymbolTable()
    for v in x:
        if v in st:
            st[v] += 1
        else:
            st[v] = 1
    return st

def g(x):
    return sum(f(x).values())

def h(x):
    y = f(x)
    z = max(y.values())
    for v in y.keys():
        if y[v] == z:
            return v
    return -1
```

a. What is the value of the expression `f('abracadabra')['r']`?

(A) `3`
(B) `1`
(C) `4`
(D) `5`
(E) `2`

b. What does `g('abracadabra')` return?

(A) `13`
(B) `14`
(C) `15`
(D) `11`
(E) `12`

c. What does `h('abracadabra')` return?

(A) `'c'`
(B) `'a'`
(C) `'d'`
(D) `'r'`
(E) `'b'`

d. What is the value of the expression `g('abracadabra') * h('alakazam')`?

(A) `'88888888'`
(B) `'aaaaaaaa'`
(C) `'aaaaaaaaaaa'`
(D) `88`
(E) `'88888888888'`

Problem 3. Consider an immutable data type called `Quadratic` that represents the quadratic function $ax^2 + bx + c$, where $a(\neq 0), b, c$ are integers and x is real, and supports the following API:

`quadratic.Quadratic`

`Quadratic(a, b, c)`	constructs a quadratic function `q` given the values of the coefficients `a`, `b`, and `c`
`q.coeffs()`	returns the coefficients of `q` as a tuple
`q[x]`	returns the value of `q` evaluated at `x` (eg, $x^2 + 2x + 3$ evaluates to 6 at $x = 1$)
`q.root1()`	returns the first root $\frac{-b+\sqrt{b^2-4ac}}{2a}$ of `q`
`q.root2()`	returns the second root $\frac{-b-\sqrt{b^2-4ac}}{2a}$ of `q`
`p == q`	returns `True` if `p` and `q` represent the same quadratic function (ie, their coefficients are the same), and `False` otherwise
`p + q`	returns a `Quadratic` object representing sum of quadratic functions `p` and `q` (eg, if $p = -x^2 + 2x + 3$ and $q = 2x^2 - 4x - 2$, then $p + q = x^2 - 2x + 1$)
`str(p)`	returns a string representation of `q` (eg, `"1x^2 + 2x + 3"`)

Now consider the quadratic function $q = x^2 - 7x + 12$.

a. How do you create a `Quadratic` object to represent q?

(A) `q = Quadratic([1, -7, 12])`

(B) `q = Quadratic(1, 12, -7)`

(C) `q = Quadratic([1, 12, -7])`

(D) `q = [1, -7, 12]`

(E) `q = Quadratic(1, -7, 12)`

b. What is the value of the expression `max(q.coeffs())`?

(A) `1`

(B) `12`

(C) `7`

(D) `-7`

(E) `6`

c. What is the value of the expression `q[5]`?

(A) `12`

(B) `1`

(C) `-10`

(D) `-7`

(E) `2`

d. What does the expression `q[5]` translate to internally?

(A) `__getitem__(q, 5)`

(B) `q.__getitem__(self, 5)`

(C) `Quadratic.__getitem__(q, 5)`

(D) `q.__getitem__(5)`

(E) `__getitem__(self, 5)`

e. Which of the following is a root of q?

(A) `5`

(B) `7`

(C) `3`

(D) `9`

(E) `1`

f. If `u` and `v` are `Quadratic` objects, what does the expression `u == v` translate to internally?

(A) `u.__eq__(v)`

(B) `u.__eq__(self, v)`

(C) `__eq__(self, u, v)`

(D) `__eq__(u, v)`

(E) `Quadratic.__eq__(u, v)`

g. If `u`, `v`, and `w` are `Quadratic` objects, what does the expression `u + v + w` translate to internally?

(A) `u.__add__(v.__add__(w))`

(B) `Quadratic.__add__(u, v, w)`

(C) `(__add__(u, v)).__add__(w)`

(D) `(u.__add__(v)).__add__(w)`

(E) `__add__(u, v, w)`

h. What is the expression for computing the sum of the two roots of `q`?

(A) `root1(q) + root2(q)`

(B) `root(q, 1) + root(q, 2)`

(C) `q.root(1, 2)`

(D) `q.root(1) + q.root(2)`

(E) `q.root1() + q.root2()`

Problem 4. Consider sorting the following array of strings `a` using insertion sort (shown below), by making the call `sort(a)`:

A F G L X H C P Q Z

```
def sort(a, key=None):
    n = len(a)
    for i in range(1, n):
        for j in range(i, 0, -1):
            v, w = a[j], a[j - 1]
            if key:
                v, w = key(v), key(w)
            if v >= w:
                break
            _exchange(a, j, j - 1)
```

a. When `i = 5`, where does the corresponding item `H` get sorted (ie, what is its index) relative to the items before?

(A) 2

(B) 4

(C) 5

(D) 3

(E) 1

b. When `i = 7`, where does the corresponding item `C` get sorted?

(A) 4

(B) 3

(C) 5

(D) 2

(E) 1

c. When the sorting is complete, what is the value of `a[8]`?

(A) X

(B) A

(C) Z

(D) P

(E) Q

Problem 5. Consider the following table, which gives the running time $T(n)$ in seconds for a program for various values of the input size n:

n	$T(n)$
1000	3
2000	12
4000	48
8000	192

a. What is the value of $T(n)$ if $n = 16000$?

(A) 576

(B) 1536

(C) 192

(D) 768

(E) 384

b. What is the running time classification for the program?

(A) Linear

(B) Logarithmic

(C) Quadratic

(D) Linearithmic

(E) Cubic

Problem 6. Suppose that a minus sign in the input indicates pop the stack and write the return value to standard output, and any other string indicates push the string onto the stack. Further suppose that following input is processed:

```
A B - C D - E F G - - H I J - - - K L - M N O -
```

a. What is the *fifth* string in standard output?

(A) `J`

(B) `G`

(C) `I`

(D) `F`

(E) `H`

b. What are the contents (top to bottom) left on the stack?

(A) `A C E K M N`

(B) `N M K E C A`

(C) `M K E C A N`

(D) `C E K M N A`

(E) `K E C A N M`

Problem 7. Suppose that a minus sign in the input indicates dequeue the queue and write the return value to standard output, and any other string indicates enqueue the string into the queue. Further suppose that following input is processed:

```
A B - C D - E F G - - H I J - - - K L - M N O -
```

a. What is the *last* string in standard output?

(A) `J`

(B) `G`

(C) `F`

(D) `I`

(E) `H`

b. What are the contents (front to back) left on the queue?

(A) `O N M L K J`

(B) `M K E C A N`

(C) `J K L M N O`

(D) `C E K M N A`

(E) `K E C A N M`

Answers

Problem 1. E, C, A, C

Problem 2. E, D, B, C

Problem 3. E, B, E, D, C, A, D, E

Problem 4. D, E, A

Problem 5. D, C

Problem 6. A, B

Problem 7. D, C