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:

```python
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 'zbrzacdbzrz'
C 'azracadabra'
D 'abvradabwa'
E 'azracadazra'

Initials: 1 / 8
b. What does \( g(\text{'abracadabra'}) \) return?

A 15
B 11
C 13
D 14
E 12

c. What does \( g(\text{'abracadabra', 'parrot'[2:4]}) \) return?

A 4
B 2
C 1
D 3
E 0

d. What does \( g(f(\text{'abracadabra', 'abcdr'[3], 'vwxyz'[4]})) \) return?

A 7
B 1
C 6
D 2
E 4

Problem 2. Consider the following functions:

```python
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
```

Initials: 2 / 8
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 16
   - 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 \( g('abracadabra') \times h('alakazam') \)?
   - 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:
Now consider the quadratic function \( q = x^2 - 7x + 12 \).

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

A. \( q = \text{Quadratic}([1, -7, 12]) \)

B. \( q = \text{Quadratic}(1, 12, -7) \)

C. \( q = \text{Quadratic}([1, 12, -7]) \)

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

E. \( q = \text{Quadratic}(1, -7, 12) \)

d. What is the value of the expression \( \max(q.\text{coeffs}) \)?

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. (u\_add\_(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):
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 A 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 2  
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 \( n \):

<table>
<thead>
<tr>
<th>( n )</th>
<th>( T(n) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>3</td>
</tr>
<tr>
<td>2000</td>
<td>12</td>
</tr>
<tr>
<td>4000</td>
<td>48</td>
</tr>
<tr>
<td>8000</td>
<td>192</td>
</tr>
</tbody>
</table>

a. What is the value of \( T(n) \) if \( n = 16000 \)?
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 K E C A
C  K E C A N
D  C E K M N A
E  K E C A N

**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 -

Initials: 7 / 8
a. What is the last string in standard output?

A
B
C
D
E
J
G
F
I
H

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

A
B
C
D
E
O H M L K J
M K E C A N
J K L M N O
C E K M N A
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