INSTRUCTIONS

- You have 2 hours to complete the exam.
- The exam is closed book, closed notes, closed computer, closed calculator, except one hand-written 8.5" × 11" crib sheet of your own creation and the official CS 61A midterm 1 study guide.
- Mark your answers on the exam itself. We will not grade answers written on scratch paper.

<table>
<thead>
<tr>
<th>Last name</th>
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<tbody>
<tr>
<td>First name</td>
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<tr>
<td>Student ID number</td>
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<td>CalCentral email (<a href="mailto:_@berkeley.edu">_@berkeley.edu</a>)</td>
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<td>Name of the person to your left</td>
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<td>Name of the person to your right</td>
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</table>

Policies & clarifications

- If you need to use the restroom, bring your phone and exam to the front of the room.
- You may use built-in Python functions that do not require import, such as \texttt{min}, \texttt{max}, \texttt{pow}, \texttt{len}, and \texttt{abs}.
- You \textbf{may not} use example functions defined on your study guides unless a problem clearly states you can.
- For fill-in-the-blank coding problems, we will only grade work written in the provided blanks. You may only write one Python statement per blank line, and it must be indented to the level that the blank is indented.
- Unless otherwise specified, you are allowed to reference functions defined in previous parts of the same question.
1. (10 points) What Would Python Display

For each of the expressions in the table below, write the output displayed by the interactive Python interpreter when the expression is evaluated. The output may have multiple lines. If an error occurs, write “Error”, but include all output displayed before the error. If evaluation would run forever, write “Forever”. To display a function value, write “Function”. The first two rows have been provided as examples.

The interactive interpreter displays the value of a successfully evaluated expression, unless it is None.

Assume that you have first started python3 and executed the statements on the left.

```python
identity = lambda x: x
increment = lambda x: x + 1

def fif(c, t, f, x):
    if c(x):
        return t(x)
    else:
        return f(x)

def bounce(x, y):
    while x < y:
        if x <= (y and x):
            print('a')
        if x > 0:
            print('b')
        elif x > -5:
            print('c')
        x, y = -y, increment(x - y)
    print(y)

crazy = lambda rich: 100 * rich
crazy = lambda rich: crazy(crazy(rich))

def ok(py):
    def h(w):
        print(py // 10)
        return ok(py)
    return lambda h: h(py)
```

<table>
<thead>
<tr>
<th>Expression</th>
<th>Interactive Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>pow(10, 2)</td>
<td>100</td>
</tr>
<tr>
<td>print(4, 5) + 1</td>
<td>4 5 Error</td>
</tr>
<tr>
<td>print(None, print(1, 2))</td>
<td>None None</td>
</tr>
<tr>
<td>fif(abs, print, print, -2)</td>
<td>-2</td>
</tr>
<tr>
<td>bounce(1, 2)</td>
<td>a b 0 a c -1</td>
</tr>
<tr>
<td>crazy(88)</td>
<td>Error/Forever</td>
</tr>
<tr>
<td>ok(314)(identity)</td>
<td>314</td>
</tr>
</tbody>
</table>

2. (4 points) Implement factorial, which computes the factorial of a positive integer n. You may use any of the functions defined above. You may not write if, else, and, or, or lambda in your solution.

```python
def factorial(n):
    """The factorial of positive n: n * (n-1) * (n-2) * ... * 1
    """
    return n * fif(identity, factorial, increment, n-1)
```

```python
>>> factorial(4) # 4 * 3 * 2 * 1
24
>>> factorial(1)
1
"""
```
3. (6 points) Also Some Meal

Fill in the environment diagram that results from executing the code on the right until the entire program is finished, an error occurs, or all frames are filled. *You may not need to use all of the spaces or frames.* A complete answer will:

- Add all missing names and parent annotations to all local frames.
- Add all missing values created or referenced during execution.
- Show the return value for each local frame.

```python
def al(so):
    me = 1
    def al(to):
        return so + me
    so = 2
    return al

def me(al):
    me = 3
    return al(lambda: 4) + so

so = 5
so = me(al(6)) + so
```

---

Global frame

<table>
<thead>
<tr>
<th>al</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>me</td>
<td></td>
</tr>
<tr>
<td>so</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

f1: al [parent=Global]

<table>
<thead>
<tr>
<th>so</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>al</td>
<td></td>
</tr>
<tr>
<td>me</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

func al(to) [parent=f1]

f2: me [parent=Global]

<table>
<thead>
<tr>
<th>al</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>me</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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</table>

Return Value 8

f3: al [parent=f1]

<table>
<thead>
<tr>
<th>to</th>
<th></th>
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</thead>
<tbody>
<tr>
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func λ() <line 10> [parent=f2]

Return Value 3
4. (5 points) Getting Rect

Implement rect, which takes two positive integer arguments, perimeter and area. It returns the integer length of the longest side of a rectangle with integer side lengths $\ell$ and $h$ which has the given perimeter and area. If no such rectangle exists, it returns False.

The perimeter of a rectangle with sides $\ell$ and $h$ is $2\ell + 2h$. The area is $\ell \cdot h$.

Hint: The built-in function round takes a number as its argument and returns the nearest integer. For example, round(2.0) evaluates to 2, and round(2.5) evaluates to 3.

def rect(area, perimeter):
    """Return the longest side of a rectangle with AREA and PERIMETER that has integer sides."

    side = 1
    while side * side <= area:
        other = round(perimeter / 2 - side)

        if side * other == area and 2 * (side + other) == perimeter:
            return other

        side = side + 1

    return False
5. (6 points)  Dig It

Implement sequence, which takes a positive integer n and a function term. It returns an integer whose digits show the n elements of the sequence term(1), term(2), ..., term(n) in order. Assume the term function takes a positive integer argument and returns a positive integer.

Important: You may not use pow, **, log, str, or len in your solution.

```python
def sequence(n, term):
    """Return the first n terms of a sequence as an integer."

    >>> sequence(6, abs)  # Terms are 1, 2, 3, 4, 5, 6
    123456
    >>> sequence(5, lambda k: k+8)  # Terms are 9, 10, 11, 12, 13
    910111213
    >>> sequence(4, lambda k: pow(10, k))  # Terms are 10, 100, 1000, 10000
    10100100010000

    t, k = 0, 1
    while k <= n:
        m = 1
        x = term(k)
        while m <= x:
            m *= 10
            t = t * m + x
        k = k + 1
    return t
```
6. (9 points) This Again?

Definitions. A repeatable integer function takes an integer argument and returns a repeatable integer function.

(a) (6 pt) Implement repeat, which is a repeatable integer function that detects repeated arguments. As a side effect of repeated calls, it prints each argument that has been used before in a sequence of repeated calls. Therefore, if an argument appears \( n \) times, it is printed \( n - 1 \) times in total, each time other than the first. The detector function is part of the implementation of repeat; you must determine how it is used.

Important: You may not use a list, set, or any other data type not covered yet in the course.

```python
def repeat(k):
    """When called repeatedly, print each repeated argument."

    7
    1
    5
    1
    """

    return detector(lambda n: False)(k)

def detector(f):
    def g(i):
        if f(i):
            print(i)

        return detector(lambda n: n == i or f(n))

    return g
```

(b) (3 pt) Implement repeat_digits, which takes a non-negative integer \( n \). For the digits of \( n \) from right to left, it prints each digit that also appears somewhere to its right. Assume repeat is implemented correctly.

```python
def repeat_digits(n):
    """Print the repeated digits of non-negative integer n."

    >>> repeat_digits(581002821)
    2
    0
    1
    8
    """

    f = repeat

    while n:
        f, n = f(n % 10), n // 10