Announcements

- Prelim 2 Thurs Apr 22 at 6:30 - 8pm (university-scheduled)
  - Your seat or Zoom link will be assigned this afternoon via CMS
  - In-person: Bring pens/pencils/erasers (bring several). Bring a watch or even an actual clock if you have one. No smart watches/phones! You may not be able to see the wall clock in Barton from your seat. Bring Cornell ID.
  - Online: Different this time: log on to Zoom proctor session on both devices. Students who have not done a mock exam (for Prelim 1) will be contacted to do one.
- Labs this week: Prelim 2 review, focus on class methods
- Thurs Apr 22 lecture time → office hours
Studying for the Exam

• Read study guide. Notes differences among the semesters

• Review all labs and assignments
  ▪ You should be able to do all problems now

• Look at exams from past years
  ▪ Exams with solutions on course web page
  ▪ Refer to info in study guide regarding differences among the semesters
Prelim 2 Topics

- **Topics after prelim 1:**
  - Recursion
  - Classes

- **Topics before but not on prelim 1:**
  - Nested lists
  - Iteration with nested loops
  - Dictionaries and tuples

While-loop *not* on Prelim 2
Recursion: Before You Begin

• Plan out how you will approach the task before writing code
• Consider the following:
  ▪ How can you “divide and conquer” the task?
  ▪ Do you understand the spec?
  ▪ How would you describe the implementation of the function using words?
Recursion

1. Base case
2. Recursive case
3. Ensure the recursive case makes progress towards the base case
Base Case

- Create cases to handle smallest units of data
- Depends on what type of data is being processed and what the function must do to that data
## Base Case Examples

<table>
<thead>
<tr>
<th>Strings</th>
<th>Lists</th>
<th>Point3 objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Element</td>
<td>“5”</td>
<td>[5]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 Elements</td>
<td>“”</td>
<td>[]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>None</td>
</tr>
</tbody>
</table>

Table showing examples of strings, lists, and Point3 objects for base case scenarios.
Recursive Case

• Divide and conquer: how to divide the input so that we can call the function recursively on smaller input
• When calling the function recursively, assume that it works exactly as the specification states it does -- don’t worry about the specifics of your implementation here
• Use this recursive call to handle the rest of the data, besides the small unit being handled
Make Progress

- Recursive calls must always make some sort of “progress” towards the base cases
- This is the only way to ensure the function terminates properly
- Risk having infinite recursion otherwise
def filter(nlist):
    """Return: a copy of nlist with all negative numbers removed.
    The order of the original list is preserved
    Example: filter([1,-1,2,-3,-4,0]) returns [1,2,0]
    Precondition: nlist is a (possibly empty) list of numbers."""
def histogram(s):
    """Return: a histogram (dictionary) of the # of letters in string s.

    The letters in s are keys, and the count of each letter is the value. If
    the letter is not in s, then there is NO KEY for it in the histogram.

    Example: histogram("") returns {},
    histogram('abracadabra') returns {'a':5, 'b':2, 'c':1, 'd':1, 'r':2}

    Precondition: s is a string (possibly empty) of just letters."""

Dictionaries (Type dict)

>>> d = {'ec1':'Ezra', 'ec2':'Ezra', 'tm55':'Toni'}
>>> d['ec1']
'Ezra'
>>> d[0]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 0
>>> d[:1]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unhashable type: 'slice'

- Can access elements like a list
- Must use the key, not an index
- Cannot slice ranges
Iteration with For-Loops

Two ways to implement the for-loop

for x in alist:
  • x is each value inside the list
  • Modifying x does not modify the list

for x in range(len(alist)):
  • x represents each index of the list
  • Modifying alist[x] modifies the list
def max_cols(table):
    """Returns: List storing max value of each column

    We assume that table is a 2D list of floats (so it is a list of rows and each row has the same number of columns. This function returns a new list that stores the maximum value of each column.)

    Examples:
    max_cols([[1,2,3], [2,0,4], [0,5,2]]) is [2,5,4]
    max_cols([[1,2,3]]) is [1,2,3]

    Precondition: table is a NONEMPTY 2D list of floats
    Built-in function max not allowed. """"
Questions?  Next up: Office Hours
Recursion with Objects

class TreeNode (object):
    
    Attributes:
    value: An int, the “value” of this TreeNode object
    left: A TreeNode object, or None
    right: A TreeNode object, or None

```python
class TreeNode (object):
    """Attributes:
    value: An int, the “value” of this TreeNode object
    left: A TreeNode object, or None
    right: A TreeNode object, or None"
```
Understanding the Object’s Structure
Recursion with Objects

```python
def contains (t, v):
    """
    Return: True if any of the TreeNode objects in the entire “tree” have the value v
    
    Define the “tree” as the TreeNode t, as well as the TreeNodes accessible through the left and right attributes of t (if not None)
    Preconditions: t is a TreeNode, or None. v is an int.
    """
```
Divide and Conquer on Trees

Recall the tree structure...

They can be easily divided into left and right subtrees!

Recursion on left
Recursion on right
Put result back together