# Announcements for This Lecture

## Readings
- Today: Chapter 11
- Next Week: Sec. 5.8-5.10

## Assignments
- A3 is due **tomorrow**
  - Turn in before you leave
- Opportunities for help
  - Consultants 4:30-9:30
  - Wil has OH 9-10, Fri
  - Max has OH 1-2, Fri
- Survey is posted in CMS
  - Due on day of exam
- A4 posted **after** the exam

### Prelim, Oct 15th 7:30-9:00
- Material up to **TUESDAY**
- Study guide is posted

### Review session Wednesday
- Still checking place/time
- Announcement on Piazza
Processing Lists: builtins

- `sum(x)` adds up all the elements in the list `x`
  - They must all be numbers!

- `min(x)` or `max(x)` find the min/max value in list `x`
  - They use the same ordering as `sort()`

- `range(a,b,c)` produces `[a, a+c, a+2*c, ..., a+c*((b-a)/c)]`
  - Starts at `a`, increases by `c` each time, until `b` (or less)
  - The argument `c` is optional; `c = 1` by default

- `list(x)` converts `x` (such as a string) to a list
  - Example: `list('mimsy')` produces `['m', 'i', 'm', 's', 'y']`
The Map Function

- **map(\langle function \rangle, \langle list \rangle)**
  - Function has to have exactly **1 parameter**
  - Otherwise, get an error
  - Returns a new list
- Does the same thing as

```python
def map(f, x):
    result = []  # empty list
    for y in x:
        result.append(f(y))
    return result
```

```
map(len, ['a', 'bc', 'defg'])
returns [1, 2, 4]
```
Lists of Objects

- List positions are variables
  - Can store base types
  - But cannot store folders
  - Can store folder identifiers
- Folders linking to folders
  - Top folder for the list
  - Other folders for contents
- Example:
  >>> \texttt{r = colormodel.RED}
  >>> \texttt{b = colormodel.BLUE}
  >>> \texttt{g = colormodel.GREEN}
  >>> \texttt{x = [r, b, g]}

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More Sequences
Lists of Objects

- List positions are variables
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  - But cannot store folders
  - Can store folder identifiers
- Folders linking to folders
  - Top folder for the list
  - Other folders for contents

Example:
```python
g = colormodel.RED
>>> b = colormodel.BLUE
>>> g = colormodel.GREEN
>>> x = [r, b, g]
```
Nested Lists

• Lists can hold any objects
• Lists are objects
• Therefore lists can hold other lists!

\[
\begin{align*}
a &= [2, 1] \\
b &= [3, 1] \\
c &= [1, 4, b] \\
x &= [1, a, c, 5]
\end{align*}
\]

\[
x = [1, [2, 1], [1, 4, [3, 1]], 5]
\]
Two Dimensional Lists

Table of Data

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>4</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>8</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

Images

Each row, col has a value

Each row, col has an RGB value

Store them as lists of lists (row-major order)

\[ d = [[5,4,7,3],[4,8,9,7],[5,1,2,3],[4,1,2,9],[6,7,8,0]] \]
Overview of Two-Dimensional Lists

- Access value at row 3, col 2:
  \[ d[3][2] \]
- Assign value at row 3, col 2:
  \[ d[3][2] = 8 \]
- An odd symmetry
  - Number of rows of \( d \): \( \text{len}(d) \)
  - Number of cols in row \( r \) of \( d \): \( \text{len}(d[r]) \)
How Multidimensional Lists are Stored

- \( b = [[9, 6, 4], [5, 7, 7]] \)

- \( b \) holds name of a one-dimensional list
  - Has \( \text{len}(b) \) elements
  - Its elements are (the names of) 1D lists
- \( b[i] \) holds the name of a one-dimensional list (of ints)
  - Has \( \text{len}(b[i]) \) elements
Image Data: 2D Lists of Pixels

b[0][0] is a white pixel

RGB
red 255
green 255
blue 255

id1

list

id2
id3...

id2
id23
id24...

id23
Ragged Lists: Rows w/ Different Length

- \( b = \begin{bmatrix} 17, 13, 19 \end{bmatrix}, \begin{bmatrix} 28, 95 \end{bmatrix} \)

- Will see applications of this later
Slices and Multidimensional Lists

- Only “top-level” list is copied.
- Contents of the list are not altered
- \( b = [[9, 6], [4, 5], [7, 7]] \)

\[
x = b[:2]
\]
Slices and Multidimensional Lists

- Only “top-level” list is copied.
- Contents of the list are not altered
- \( b = [[9, 6], [4, 5], [7, 7]] \)

\[ x = b[:2] \]
Slices and Multidimensional Lists

- Create a nested list
  
  ```python
  >>> b = [[9,6],[4,5],[7,7]]
  ```

- Get a slice
  
  ```python
  >>> x = b[:2]
  ```

- Append to a row of x
  
  ```python
  >>> x[1].append(10)
  ```

- x now has nested list
  
  ```python
  [[9, 6], [4, 5, 10]]
  ```

- What are the contents of the list (with name) in b?

  A: `[[9,6],[4,5],[7,7]]`
  B: `[[9,6],[4,5,10]]`
  C: `[[9,6],[4,5,10],[7,7]]`
  D: `[[9,6],[4,10],[7,7]]`
  E: I don’t know
Slices and Multidimensional Lists

• Create a nested list
  >>> b = [[9,6],[4,5],[7,7]]

• Get a slice
  >>> x = b[:2]

• Append to a row of x
  >>> x[1].append(10)

• x now has nested list
  [[9, 6], [4, 5, 10]]

• What are the contents of the list (with name) in b?

  A: [[9,6],[4,5],[7,7]]
  B: [[9,6],[4,5,10]]
  C: [[9,6],[4,5,10],[7,7]]
  D: [[9,6],[4,10],[7,7]]
  E: I don’t know
def transpose(table):
    """Returns: copy of table with rows and columns swapped
    Precondition: table is a (non-ragged) 2d List"""
    numrows = len(table)
    numcols = len(table[0])  # All rows have same no. cols
    result = []  # Result accumulator
    for m in range(numcols):
        row = []  # Single row accumulator
        for n in range(numrows):
            row.append(table[n][m])  # Build up row
        result.append(row)  # Add result to table
    return result
## Dictionaries (Type `dict`)

### Description

- List of **key-value** pairs
  - Keys are unique
  - Values need not be
- Example: net-ids
  - net-ids are **unique** (a key)
  - names need not be (values)
  - `js1` is John Smith (class ’13)
  - `js2` is John Smith (class ’16)
- Many other applications

### Python Syntax

- Create with format: `{k1:v1, k2:v2, ... }
- Keys must be non-mutable
  - ints, floats, bools, strings
  - **Not** lists or custom objects
- Values can be anything
- Example:

  ```python
d = {'js1':'John Smith',
      'js2':'John Smith',
      'wmw2':'Walker White'}
  ```
Using Dictionaries (Type dict)

- Access elts. like a list
  - `d['js1']` evaluates to 'John'
  - But cannot slice ranges!

- Dictionaries are **mutable**
  - Can reassign values
    - `d['js1'] = 'Jane'`
  - Can add new keys
    - `d['aal'] = 'Allen'`
  - Can delete keys
    - `del d['wmw2']`

```
d = {'js1': 'John', 'js2': 'John', 'wmw2': 'Walker'}
```

Key-Value order in folder is not important
Using Dictionaries (Type `dict`)

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Using Dictionaries (Type `dict`)

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```
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22
```

```
d = {'js1':'John','js2':'John',
     'wmw2':'Walker'}
```

- Deleting key deletes both
Dictionaries and For-Loops

- Dictionaries != sequences
  - Cannot slice them

- Different inside for loop
  - Loop variable gets the key
  - Then use key to get value

- Has methods to convert dictionary to a sequence
  - Seq of keys: `d.keys()`
  - Seq of values: `d.values()`
  - Key-value pairs: `d.items()`

```python
for k in d:
    # Loops over keys
    print k  # key
    print d[k]  # value

# To loop over values only
for v in d.values():
    print v  # value
```

See grades.py

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More Sequences