Announcements

- Last Day of class!
- Assign 9 by Monday, none accepted after that
- Assign 8, late by Friday, Dec 8!
- APT 8 due tonight, late by Sunday
- Form for taking Final exam another time
  - accommodations?

More Announcements

- Regrade for Exam 2 – submit by today
- Last Consulting Hours tonight
- Prof. Rodger extra office hours this week
  - Today 4:45-5:45pm, Friday 2:30-4:30pm
- **Review Session** Tues, Dec 12
  - LSRC B101, 4pm-5:30pm
- Concern form on forms page

Calculate Your Grade

- From “About” tab on course web page

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labs</td>
<td>5%</td>
</tr>
<tr>
<td>Reading Quizzes</td>
<td>5%</td>
</tr>
<tr>
<td>Lecture Group work</td>
<td>5%</td>
</tr>
<tr>
<td>Apts</td>
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<tr>
<td>Programming Assignments</td>
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<tr>
<td>APT Quizzes</td>
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<tr>
<td>Two Midterm Exams</td>
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</tr>
<tr>
<td><strong>final exam</strong></td>
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More on Grades

• Lecture – ignore the first two weeks (drop/add period), plus drop 4 points
• Reading Quizzes – will drop 30 points
  • Check your grades to make sure they copied over – fill out duke oit help form if they are wrong
• Lab – drop 6 points (each lab is 4 pts)
  • 44 pts total – 38 pts is 100%
  • Lab 11 covers two new topics!

Final Exam

• Sec 01 – Thurs, Dec 14, 9am, LSRC B101
• Sec 02 – Sat, Dec 16, 2pm, LSRC B101
• Closed Book, Closed Notes, Closed neighbor
• Python Reference Sheet
• Covers all topics through today
• Best way to study is practice writing code!
• See old tests (no old final exams)

Final Exam (cont)

• Test format
  – Multiple choice
  – Writing code – similar to exam 2
• Topics include:
  – if, loops, lists, sets, dictionaries, files, functions, sorting, etc
  – recursion, regular expressions – reading level only

Time for
Duke Course Eval and Seven Steps

1. Please fill out Duke Course Eval on DukeHub now
   1. Only 17% have filled it in as of last night

2. Anonymous feedback on the Seven Steps
   Announcement on Sakai and I emailed you
Review - Selection Sort

• Sort a list of numbers.
• Idea:
  – Repeat til sorted
    • Find the smallest element in part of list not sorted
    • Put it where it belongs in sorted order.
      • Swap it with the element where it should be
• Sort example

![Selection Sort – red area sorted](image)

Selection Sort (cont.)

1 3 4 9 5 6 - end of 3rd pass

1 3 4 9 5 6 - find smallest, swap

1 3 4 5 9 6 - end of 4th pass

1 3 4 5 9 6 - find smallest, swap

1 3 4 5 6 9 - end of 5th pass, done

Review Bubble Sort

• Sort a list of numbers.
• Idea:
  – Repeat til sorted
    • Compare all adjacent pairs, one at a time. If out of order then swap them
• Sort example

![Review Bubble Sort](image)
Bubble Sort – red area sorted

9 5 4 1 3 6 - compare, swap
5 9 4 1 3 6 - compare, swap
5 4 9 1 3 6 - compare, swap
5 4 1 9 3 6 - compare, swap
5 4 1 3 9 6 - compare, swap
5 4 1 3 6 9 - end of 1st pass
5 4 1 3 6 9

Two more passes would guarantee sorted.
Or Check if sorted and skip last two passes

Bubble Sort – red area sorted

5 4 1 3 6 9 - compare, swap
4 5 1 3 6 9 - compare, swap
4 1 5 3 6 9 - compare, swap
4 1 3 5 6 9 - compare, no swap
4 1 3 5 6 9 - end of 2nd pass
4 1 3 5 6 9

Insertion Sort

• Sort a list of numbers.
• Idea:
  – Sort by repeated inserting another element
    • Leftmost element is sorted part of list
    • Insert another element in that sublist keeping it sorted
    • Insert another element in that sublist keeping it sorted
    • Etc.
• Sort example

Sorted relative to each other

???
Insertion Sort – red area sorted

9 5 1 4 3 6 - insert 5
5 9 1 4 3 6 - 1st pass, now insert 1
1 5 9 4 3 6 - 2nd pass, now insert 4
1 4 5 9 3 6 - 3rd pass, now insert 3
1 3 4 5 9 6 - 4th pass, now insert 6

• Sort the list of numbers using InsertionSort.
• The body of the loop is one pass.
• Show the elements after each pass.
• [6, 4, 9, 7, 1, 3]
Insertion Sort – red area sorted

1 3 4 6 7 9 - 5th pass

Merge Sort
- Idea: Divide and Conquer
- Divide list into two halves
- Sort both halves (smaller problem)
- Merge the two sorted halves

9 5 1 4 3 6 2 7

What does recursively sort mean?

Merge Sort
- Use the same Merge Sort algorithm
  - Divide list into two halves
  - Sort both halves (smaller problem)
  - Merge the two sorted halves

9 5 1 4

9 5 1 4 3 6 2 7
9 5 1 4 3 6 2 7 divide list into 2 halves
1 4 5 9 2 3 6 7 recursively sort each half
1 2 3 4 5 6 7 9 merge the two sorted list
What does recursively sort mean?

Merge Sort

- Use the same Merge Sort algorithm
  - Divide list into two halves
  - Sort both halves (smaller problem)
  - Merge the two sorted halves

9 5 1 4
9 5 1 4 divide list into 2 halves
5 9 1 4 recursively sort each half
1 4 5 9 merge the two sorted list

MergeSort idea for code

def mergesort(data):
    n = len(data)
    if n == 1:
        return data
    else:
        d1 = mergesort(data[:n/2])
        d2 = mergesort(data[n/2:])
        return merge(d1, d2)

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Question 1
Which sort is this?
4 10 5 3 8 2
4 10 5 3 8 2
4 5 10 3 8 2
3 4 5 10 8 2
3 4 5 8 10 2
2 3 4 5 8 10

Question 2
Which sort is this?
4 10 5 3 8 2
4 2 5 3 8 10
4 2 5 3 8 10
4 2 3 5 8 10
3 2 4 5 8 10
2 3 4 5 8 10

Timingsorts.py, what sort to call?

- Simple to understand, hard to do fast and at-scale
  - Scaling is what makes computer science …
    - Efficient algorithms don't matter on lists of 100 or 1000
  - Named algorithms in 201 and other courses
    - bubble sort, selection sort, mergesort, quicksort, …
    - See next slide and TimingSorts.py

- Basics of algorithm analysis: theory and practice
  - We can look at empirical results, would also like to be able to look at code and analyze mathematically! How does algorithm scale?
New sorting algorithms happen …

- timsort is standard on…
  - Python as of version 2.3, Android, Java 7
  - According to http://en.wikipedia.org/wiki/Timsort
    - Adaptive, stable, natural mergesort with supernatural performance

- Mergesort? Fast and Stable
  - What does this mean?
  - Which is most important?
  - Nothing is faster, what does that mean?
  - Quicksort is faster, what does that mean?

TimingSorts.py

<table>
<thead>
<tr>
<th>size</th>
<th>create</th>
<th>bubble</th>
<th>select</th>
<th>timsort</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>0.026</td>
<td>0.127</td>
<td>0.081</td>
<td>0.002</td>
</tr>
<tr>
<td>2000</td>
<td>0.045</td>
<td>0.537</td>
<td>0.273</td>
<td>0.001</td>
</tr>
<tr>
<td>3000</td>
<td>0.058</td>
<td>1.126</td>
<td>0.646</td>
<td>0.002</td>
</tr>
<tr>
<td>4000</td>
<td>0.082</td>
<td>2.174</td>
<td>1.208</td>
<td>0.003</td>
</tr>
<tr>
<td>5000</td>
<td>0.101</td>
<td>3.521</td>
<td>1.862</td>
<td>0.003</td>
</tr>
<tr>
<td>6000</td>
<td>0.118</td>
<td>4.617</td>
<td>3.005</td>
<td>0.004</td>
</tr>
<tr>
<td>7000</td>
<td>0.168</td>
<td>7.504</td>
<td>4.237</td>
<td>0.005</td>
</tr>
<tr>
<td>8000</td>
<td>0.156</td>
<td>9.074</td>
<td>6.152</td>
<td>0.007</td>
</tr>
<tr>
<td>9000</td>
<td>0.184</td>
<td>11.611</td>
<td>8.089</td>
<td>0.007</td>
</tr>
<tr>
<td>10000</td>
<td>0.212</td>
<td>14.502</td>
<td>9.384</td>
<td>0.008</td>
</tr>
</tbody>
</table>

TimingSorts.py Questions
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Wrap up Sorting

- Some Ways to Compare sorts.
  - How many total swaps?
  - Is one faster for certain types of input?
  - Does the input matter

- Different ways to sort?
  - Over 50 sorting algorithms

- Sorting animations
  http://www.sorting-algorithms.com/
More on Sorting in CompSci 201
• Learn about this and other sorts in CompSci 201, also how to analyze them to determine which one works best.
• Python: Timsort
  – combines mergesort and insertion sort
• Shellsort
  – uses insertion sort on parts of the list repeatedly - those parts getting larger each time

Scraping email address from websites
• Suppose we want to send email to all Duke Faculty to let them know …
  – Visit Departmental website, people, faculty
  – View (HTML) Source
  – Develop regex to access email – if possible!
• RegexScraper.py
  – Python makes this simple
  – Ethical hacking?
Scraping Biology faculty

- Pattern:
  \- `mailto:(\w+\.[\w]*@\w+\.[\w]*)'`

- URL
  - https://biology.duke.edu/people/all-faculty/

- Matches (call 26 times with different URL)
  
...`('emily.bernhardt', 'duke.edu')('
('emily.bernhardt', 'duke.edu')('
('bhandawat', 'gmail.com')('
('bhandawat', 'gmail.com')('
('jboynton66', 'gmail.com')('
('jboynton66', 'gmail.com')`

Scraping Sanford/PubPol faculty

- Pattern:
  \- `'(\w+\.[\w]*)@((\w+\.[\w+]*))'`

- URL
  - https://sanford.duke.edu/people/

- Matches (call 26 times with different URL)
  
...`('schanzer', 'duke.edu')('
('steveschewel', 'gmail.com')('
('michael.schoenfeld', 'duke.edu')('
('schroeder', 'law.duke.edu')`
What is Computing? Informatics?

• What is computer science, what is its potential?
  - What can we do with computers in our lives?
  - What can we do with computing for society?
  - Will networks transform thinking/knowing/doing?
  - Society affecting and affected by computing?
  - Changes in science: biology, physics, chemistry, ...
  - Changes in humanity: access, revolution (?), ...

• Privileges and opportunities available if you know code
  - Writing and reading code, understanding algorithms
  - Majestic, magical, mathematical, mysterious, ...

Computing - solve all problems?

• Some problems can be solved 'efficiently'
  - Run large versions fast on modern computers
  - What is 'efficient'? It depends

• Some cannot be solved by computer.
  - Provable! We can't wait for smarter algorithms

• Some problems have no efficient solution
  - Provably exponential $2^n$ so for "small" n …

• Some have no known efficient solution, but
  - If one does they all do!

Problem: Traveling Band

• Band wants you to schedule their concerts.
• They don’t like to travel. Minimize the time they are on the bus!
• Given N cities, what is the best schedule (shortest distance) to visit all N cities once?

How do you calculate the best path?

• Try all paths
  - Atlanta, Raleigh, Dallas, Reno, Chicago
  - Dallas, Atlanta, Raleigh, Reno, Chicago
  - Etc.
• Would you agree to code this up?
Traveling Band questions

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<table>
<thead>
<tr>
<th>Number of Cities</th>
<th>All paths – N!</th>
<th>Time to solve - 10^9 Instructions per second</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3 million</td>
<td>&lt; sec</td>
</tr>
<tr>
<td>15</td>
<td>10^{12}</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>10^{15}</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>10^{18}</td>
<td></td>
</tr>
<tr>
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<td></td>
</tr>
</tbody>
</table>

How long?

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<td>$10^{15}$</td>
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</tr>
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<td>15</td>
<td>$10^{12}$</td>
<td>16 min</td>
</tr>
<tr>
<td>18</td>
<td>$10^{15}$</td>
<td>11 days</td>
</tr>
<tr>
<td>20</td>
<td>$10^{18}$</td>
<td>31 years</td>
</tr>
<tr>
<td>25</td>
<td>$10^{25}$</td>
<td></td>
</tr>
</tbody>
</table>

## How is Python like all other programming languages, how is it different?
A Rose by any other name…C or Java?

• Why do we use [Python | Java] in courses?
  – [is | is not] Object oriented
  – Large collection of libraries
  – Safe for advanced programming and beginners
  – Harder to shoot ourselves in the foot

• Why don't we use C++ (or C)?
  – Standard libraries weak or non-existant (comparatively)
  – Easy to make mistakes when beginning
  – No GUIs, complicated compilation model
  – What about other languages?

Find all unique/different words in a file, in sorted order

Unique Words in Python

```python
def main():
    f = open('/data/melville.txt', 'r')
    words = f.read().strip().split()
    allWords = set(words)

    for word in sorted(allWords):
        print word

if __name__ == '__main__':
    main()
```

Unique words in Java

```java
import java.util.*;
import java.io.*;
public class Unique {
    public static void main(String[] args)
        throws IOException{
        Scanner scan =
            new Scanner(new File("/data/melville.txt"));
        TreeSet<String> set = new TreeSet<String>();
        while (scan.hasNext()){
            String str = scan.next();
            set.add(str);
        }
        for(String s : set){
            System.out.println(s);
        }
    }
}
```
**Unique words in C++**

```cpp
#include <iostream>
#include <fstream>
#include <set>
using namespace std;

int main()
{
    ifstream input("/data/melville.txt");
    set<string> unique;
    string word;
    while (input >> word)
    {
        unique.insert(word);
    }
    set<string>::iterator it = unique.begin();
    for (; it != unique.end(); it++)
    {
        cout << *it << endl;
    }
    return 0;
}
```

**Unique words in PHP**

```php
<?php
$wholething = file_get_contents("file:///data/melville.txt");
$wholething = trim($wholething);
$array = preg_split("\s+", $wholething);
$uni = array_unique($array);
sort($uni);
foreach ($uni as $word)
{
    echo $word."<br>";
}
?>
```

**End with A CS Story**

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**Code for Bubblesort**

```python
def bubblesort(data):
    for j in range(len(data)-1, 0, -1):
        for k in range(0, j):
            if data[k] > data[k+1]:
                # swap the elements
                temp = data[k]
                data[k] = data[k+1]
                data[k+1] = temp
    return data
```