Algorithm Design and Analysis

COMP 4500

Who am I?
(for those of you who don't know me already)

- Dr. Barry Wittman
- Not Dr. Barry Whitman
- Education:
  - PhD and MS in Computer Science, Purdue University
  - BS in Computer Science, Morehouse College
- Hobbies:
  - Reading, writing
  - Enjoying ethnic cuisine
  - DJing
  - Lockpicking
  - Stand-up comedy

How can you reach me?

- **E-mail:** wittman1@otterbein.edu
- **Office:** Point 105
- **Phone:** (614) 823-2944
- **Office hours:** **MWF** 10:15 – 11:15 a.m.,
  MWF 2:00 – 4:00 p.m.,
  TR 10:00 – 11:15 a.m.,
  T 2:00 – 4:00 p.m.,
  R 2:00 – 5:00 p.m.,
  and by appointment
- **Website:**
  http://faculty.otterbein.edu/wittman1/

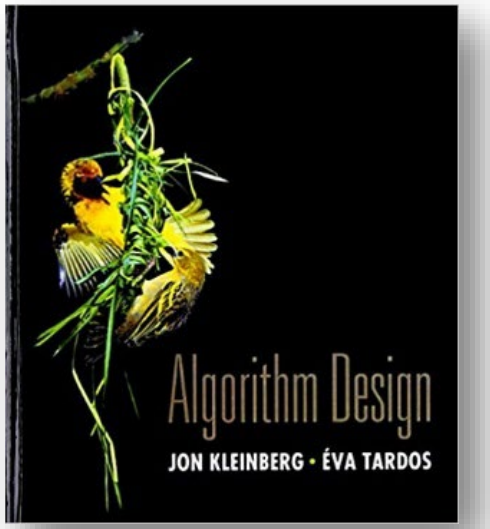
Why are we here?

- What's the purpose of this class?
- What do you want to get out of it?
- Do you want to be here?

Course Overview

Textbook

- Jon Kleinberg and Éva Tardos
- ***Algorithm Design***
- 1st Edition, 2005, Pearson
- ISBN-10: 0321295358
- ISBN-13: 978-0321295354



You have to read the book

- You are expected to read the material before class
- If you're not prepared, you will be asked to leave
  - You will forfeit the opportunity to take quizzes
  - Much more importantly, you will forfeit the education you have paid around **$100 per class meeting** to get

This is a mostly a math class

- The analysis and design of algorithms can happen independent of a computer
- Will you use the stuff in this class on a daily basis as a programmer?
  - No …
- But the stuff we talk about will be essential for interviews at Google, Amazon, etc.
- If you want to go to grad school, you'll need to know this stuff
- Maybe, just maybe, you'll get better at solving problems

Topics to be covered

- Algorithm analysis (Big Oh, Big Theta, and Big Omega)
- Graph algorithms
- Greedy algorithms
- Divide and conquer
- Dynamic programming
- Network flow
- NP-completeness
- Approximation algorithms

More information

For more information, visit the webpage:

`http://faculty.otterbein.edu/wittman1/comp4500`

- The webpage will contain:
  - The most current schedule
  - Notes available for download
  - Reminders about exams and homework
  - Syllabus
  - Detailed policies and guidelines

Homework

Seven homework assignments

- 32% of your grade will be seven equally weighted homework assignments
- Each will focus on a different set of topics from the course
- All homework is to be done individually
- I am available for assistance during office hours and through e-mail

Turning in homework

- Homework assignments must be turned in by uploading them to Blackboard **before** the deadline
- Late homework will not be accepted
- Paper copies of homework will not be accepted
- Each homework done in LaTeX will earn 0.75% extra credit toward the **final semester grade**
- Doing every homework in LaTeX will raise your final grade by 5.25% (about half a letter grade)

Three-Sentence Summaries

Three-sentence summaries

- 3% of your grade will be short summaries of the reading
- Each student will give two to three of these summaries at any time during the semester, without any warning
- Each summary should be **exactly** three sentences long
- You should write this summary before class, while doing the reading

Quizzes

Pop Quizzes

- 5% of your grade will be pop quizzes
- These quizzes will be based on material covered in the previous one or two lectures
- They will be graded leniently
- They are useful for these reasons:
  1. Informing me of your understanding
  2. Feedback to you about your understanding
  3. Easy points for you
  4. Attendance

Exams

Exams

- There will be three equally weighted in-class exams totaling 45% of your final grade
  - **Exam 1:** 2/05/2024
  - **Exam 2:** 2/28/2024
  - **Exam 3:** 4/01/2024
- The final exam will be worth 15% of your grade
  - **Final:** 8:00 – 10:00 a.m.

    4/24/2024

Course Schedule

Tentative schedule

Week	Starting	Topics	Chapters	Notes
1	01/08/24	Introduction	1 and 2	
2	01/15/24	Algorithm Analysis	2	MLK Day
3	01/22/24	Graphs	3	
4	01/29/24	Greedy Algorithms I	4	
5	02/05/24	Greedy Algorithms II	4	Exam 1
6	02/12/24	Divide and Conquer I	5	
7	02/19/24	Divide and Conquer II	5 and notes	
8	02/26/24	Dynamic Programming I	6	Exam 2
	03/04/24	**Spring Break**		
9	03/11/24	Dynamic Programming II	6	
10	03/18/24	Network Flow	7	
11	03/25/24	NP-completeness	8	Good Friday
12	04/01/24	More NP-completeness	8	Exam 3
13	04/08/24	Approximation Algorithms	11	
14	04/15/24	Review	All and notes	

Policies

Grading breakdown

- 32% • Seven homework assignments
- 3% • Three-sentence reading summaries
- 5% • Quizzes
- 45% • Three equally weighted midterm exams
- 15% • Final exam

Grading scale

A	93-100	B-	80-82	D+	67-69
A-	90-92	C+	77-79	D	60-66
B+	87-89	C	73-76	F	60-62
B	83-86	C-	70-72		

Academic dishonesty

- Don't cheat
- **First offense:**
  - I will try to give you a zero for the assignment, then lower your final letter grade for the course by one full grade
- **Second offense:**
  - I will try to fail you for the course and try to kick you out of Otterbein
- Refer to the syllabus for the school's policy
- Ask me if you have questions or concerns

Disability Services

- The University has a continuing commitment to providing access and reasonable accommodations for students with disabilities, including mental health diagnoses and chronic or temporary medical conditions
- Students who may need accommodations or would like referrals to explore a potential diagnosis are urged to contact Disability Services (DS) as soon as possible
- DS will facilitate accommodations and assist the instructor in minimizing barriers to provide an accessible educational experience
- Please contact DS at DisabilityServices@otterbein.edu
- More info can also be found at http://www.otterbein.edu/ods
- Your instructor is happy to discuss accommodations privately with you as well

Logical warmup

- Consider three boxes A, B, and C
- One contains gold, but the other two are empty
- Each box has a message printed on it
- Two of the messages are lies, and one is telling the truth
- Which box has the gold?

Big Theta of Code

Practical Big Theta

- Let's look at a number of loop based samples of Java and estimate their Big Theta bounds
- We might need the following useful relationships
- Arithmetic series: $\sum_{i=1}^{n} i = \frac{n(n+1)}{2}$ is $\theta(n^2)$
- Geometric series: $\sum_{i=0}^{n-1} r^i = \frac{1-r^n}{1-r}$
  - and the bound depends on *r*
- Harmonic series: $\sum_{i=1}^{n} \frac{1}{i}$ is $\theta(\log n)$

Far too easy

- What's the Big Theta bound if *n* is the length of **`values`**?

```
public static double average(int[] values) {
    double sum = 0.0;
    for(int i = 0; i < values.length; ++i)
        sum += values[i];
    return sum / values.length;
}
```

A little tougher

- What's the Big Theta bound if *n* is the length of **`people`**?

```
public static void meeting(Person[] people) {
     for(int i = 0; i < people.length; ++i)
          for(int j = i + 1; j < people.length; ++j)
               people[i].shakeHands(people[j]);
}
```

Watch your step

- What's the Big Theta bound if *n* is **n**?

```
public static void powers(int n) {
    int i = 1;
    while(i <= n) {
        System.out.print(i);
        i *= 2;
    }
}
```

Keep watching your step

- What's the Big Theta bound if *n* is **n**?

```
for(int i = 1; i < n; ++i)
    for(int j = 0; j < n; j += i)
        System.out.println("*");
```

Steps on steps

- What's the Big Theta bound if *n* is **n**?

```
for(int i = 1; i < n; i *= 2)
    for(int j = 1; j < n; j *= 3)
        System.out.println("#");
```

Steps on steps on steps

- What's the Big Theta bound if *n* is **n**?

```
int counter = 1;
for(int i = 1; i <= n; ++i) {
    for(int j = 0; j < counter; ++j)
        System.out.println("$");
    counter *= 2;
}
```

Switch it up

- What's the Big Theta bound if *n* is **n**?

```
int counter = 1;
for(int i = 1; i <= n; ++i) {
    for(int j = 0; j < n/counter; ++j)
        System.out.println("$");
    counter *= 2;
}
```

Back to your roots

- What's the Big Theta bound if *n* is **n**?

```
for(int i = 0; i*i < n; ++i)
    for(int j = 0; j < n; ++j)
        System.out.println("%");
```

Upcoming

Next time…

- Proof techniques (review COMP 2230)
- Asymptotic orders of growth
- Properties of asymptotic bounds

Reminders

- Read 2.1 and 2.2