a) Suppose your colleague wrote an algorithm and claims the algorithm is $O(n)$. If the algorithm takes 3 seconds to run for $n = 100$, then how long will the algorithm take to run for $n = 200$? What about $n = 700$ or $n = 1000$?

b) Suppose your colleague wrote an algorithm and claims the algorithm is $O(n^2)$. If the algorithm takes 5 seconds to run for $n = 2000$, then how long will the algorithm take to run for $n = 4000$? What about $n = 14000$ or $n = 20000$?
Practice question on complexity:

a) Suppose your colleague wrote an algorithm and claims the algorithm is $O(n)$. If the algorithm takes 3 seconds to run for $n = 100$, then how long will the algorithm take to run for $n = 200$? What about $n = 700$ or $n = 1000$?

- for $n = 200$: $3 \times \frac{200}{100} = 3 \times 2 = 6$ seconds
- for $n = 700$: $3 \times \frac{700}{100} = 3 \times 7 = 21$ seconds
- for $n = 1000$: $3 \times \frac{1000}{100} = 3 \times 10 = 30$ seconds

b) Suppose your colleague wrote an algorithm and claims the algorithm is $O(n^2)$. If the algorithm takes 5 seconds to run for $n = 2000$, then how long will the algorithm take to run for $n = 4000$? What about $n = 14000$ or $n = 20000$?
a) Suppose your colleague wrote an algorithm and claims the algorithm is $O(n)$. If the algorithm takes 3 seconds to run for $n = 100$, then how long will the algorithm take to run for $n = 200$? What about $n = 700$ or $n = 1000$?

- for $n = 200$: $3 \times (200/100) = 3 \times 2 = 6$ seconds
- for $n = 700$: $3 \times (700/100) = 3 \times 7 = 21$ seconds
- for $n = 1000$: $3 \times (1000/100) = 3 \times 10 = 30$ seconds

b) Suppose your colleague wrote an algorithm and claims the algorithm is $O(n^2)$. If the algorithm takes 5 seconds to run for $n = 2000$, then how long will the algorithm take to run for $n = 4000$? What about $n = 14000$ or $n = 20000$?

- for $n = 4000$: $5 \times (4000/2000)^2 = 5 \times (2^2) = 20$ seconds
- for $n = 14000$: $5 \times (14000/2000)^2 = 5 \times (7^2) = 245$ seconds
- for $n = 20000$: $5 \times (20000/2000)^2 = 5 \times (10^2) = 500$ seconds
Recap of course topics

- Writing pseudocode, finding bugs
- Variables, expressions, operators
- Conditionals
- Functions & modules
- Recursion
- Graphics with the Turtle
- Lists, strings and slicing
- Iteration with for loops and while loops
- Dictionaries & tuples
- Mutability
- Converting between decimal, binary, hexadecimal representations
- Binary arithmetic (addition, multiplication)
- Image processing with MiddImage
- Object-oriented programming
- Application Programming Interfaces
- Games
- Complexity
- Digital circuits
- HMMM & Assembly
Simulating physical phenomena is hard to do analytically, so we discretize using a mesh.
Which mesh is better?
Voronoi diagrams are useful for simulating physics too!
What skills are needed?

- Sets & Graphs (CS 200)
- Data structures (CS 201)
- Computer Graphics (CS 461)
- Geometric Modeling (CS 422)
- Lots of linear algebra! (MATH 200)
- Multivariable calculus (MATH 223)
Last few announcements:

- No class on Friday (tutors and I will log in for office hours in class zoom meetings)
- **Reflection** (CRF + anonymous forms about material, tutoring) **due today 05/19**
- Homework 12 due **Friday 05/21** at 11:59pm
- Final exam will be available from **Wednesday 05/26 - Friday 05/28** (due at 11:59pm)
  - please take **3 hours** to complete exam whenever you like on those days
  - **same format as midterm**: Part 1 (short answer in Canvas quiz) & Part 2 (programming in replit)
  - I will post a **study guide** by the end of this week
- Philip’s office hours:
  - Thursday 9am-10am, Friday 9:10-10am (section A), 10:20-11:10am (section B), 2pm-3pm
- Evening tutoring: [https://www.cs.middlebury.edu/~cm2/tutors/pages/cs145_rtutoring.html](https://www.cs.middlebury.edu/~cm2/tutors/pages/cs145_rtutoring.html)
  - Wednesday: 7-9pm (Manny)
  - Thursday: 7-9pm (Sabrina)
- ASI hours: [https://www.cs.middlebury.edu/~cm2/tutors/pages/asi_tutoring.html](https://www.cs.middlebury.edu/~cm2/tutors/pages/asi_tutoring.html)

please download all your repls by June 1st! **otherwise they might disappear!**
CS 145 merch?

```python
def piper(n):
    if n == 0:
        return 0
    return 1 + piper(n-1)
```