Outline Dec 7:

• Merge sort (recursive sorting)

• Fractal trees (recursive graphics)

Notes

• Office hours today! 3-5pm
• Last Ninja session tonight!
Final Exam
Studying for the final

- Exam time: **Saturday Dec 15** (week from tomorrow), **2-5pm**, Science Center 101
- We will post **study guide for recent material** soon
- Go through all notes, code, and practice problems
- Write out as many problems as you can **on paper** (then check in atom)
- Go back over old quizzes and their study guides
- Create a “**cheat-sheet**” for yourself of important concepts and examples (even though you can’t use it)
- Come to office hours on **(will post on Piazza)**
Recursive circle examples
Recursive Circles
Charlie F.
Ilana
Merge Sort
\[
\frac{n}{2^x} = 1 \\
\Rightarrow x = \log(n)
\]

append: one element
extend: a list of elements

merge: \(O(n)\)

runtime: \(O(n \cdot \log n)\)
before: \(O(n^2)\)
Recursive Trees
\[ \ell \text{ (length)} \]
\[ \alpha \text{ (angle)} \]
\[ (x, y) \quad dx = \ell \cdot \cos(\alpha) \]
\[ \ell \cdot \sin(\alpha) = dy \]
draw_tree(win, 0, 400, 750, 210, -math.pi/2)
draw_tree(win, 0, 400, 400, 210, -math.pi/4)
draw_tree(win, 1, 400, 400, 210, -math.pi/4)
draw_tree(win, 1, 400, 750, 210, -math.pi/2)
draw_tree(win, 2, 400, 750, 210, -math.pi/2)
draw_tree(win, 7, 400, 750, 210, -math.pi/2)
Order = 10
Example with oranges and leaves at the base case
Example with falling flowers

```
flwr = Flower(x, y)
flwr.draw(window)
```
Example with falling flowers