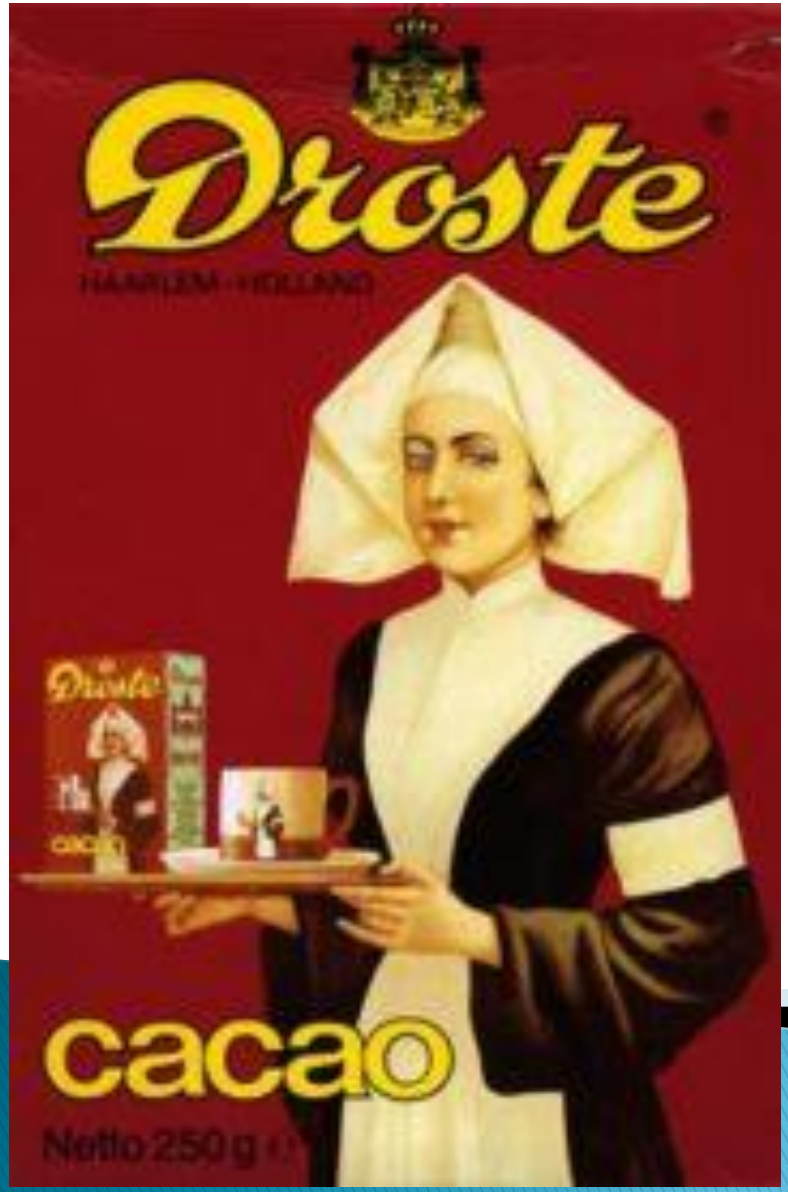


CSSE 220

Recursion

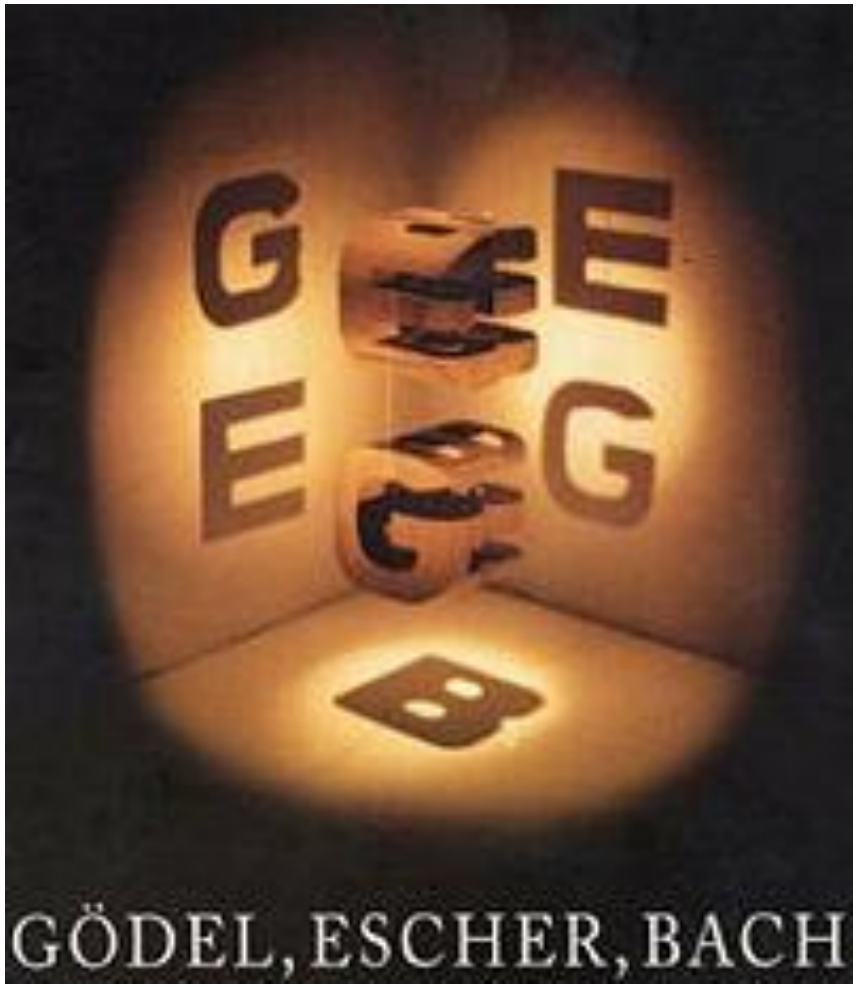
Checkout *Recursion* project from SVN

Exam 2

- Monday 10/28
- If you got a D or F on Exam 1, please be aware of this policy (from the course syllabus):
  - You **must** earn a C grade on at least one exam in order to earn a C in the course.
  - You **must** have a passing average on the exams in order to pass the course.
- Previous exams (and you know I tend to follow them closely) are posted on day 21 on the schedule

Gödel, Escher, Bach

- By Douglas Hofstadter
- Argues that a major component of intelligence is **our ability to think about thinking**



Recursion

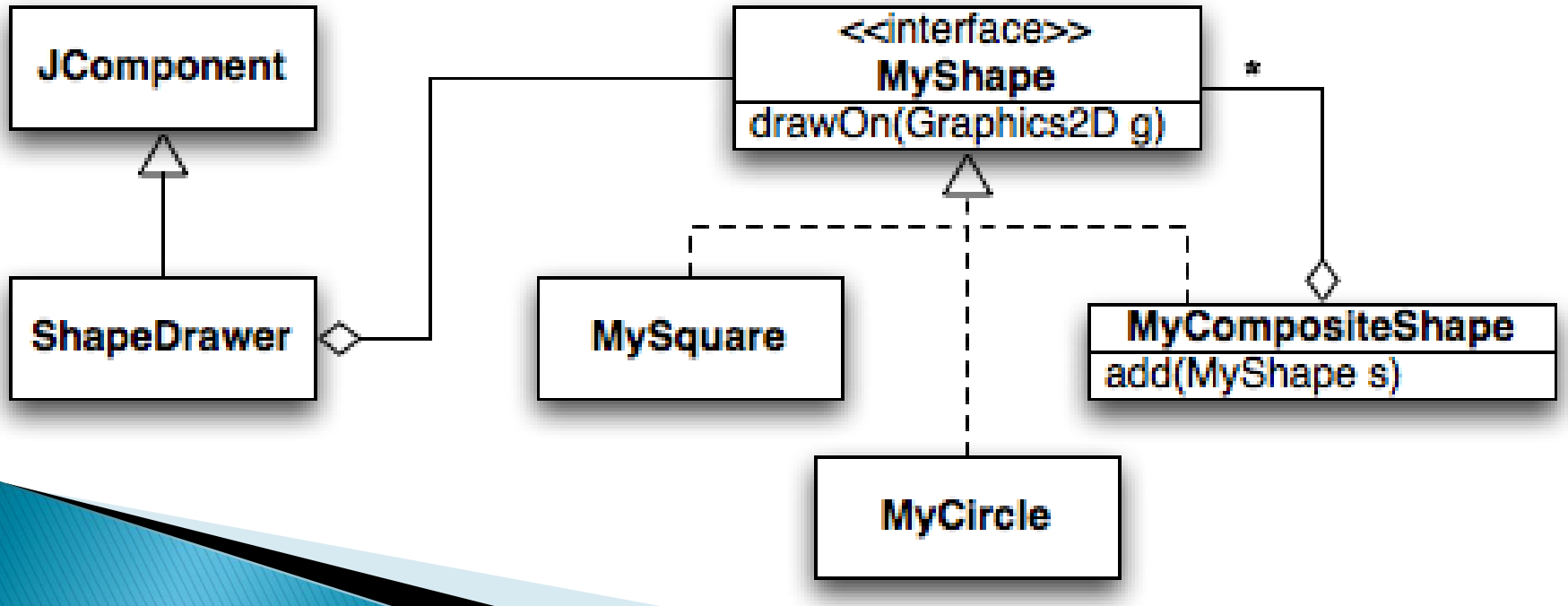
- A solution technique where the same computation **occurs repeatedly** as the problem is solved

- Examples:
  - Sierpinski Triangle: tonight's HW
  - Towers of Hanoi: http://www.mathsisfun.com/games/towerofhanoi.html or search for Towers of Hanoi

Recursion

- A solution technique where the same computation **occurs repeatedly** as the problem is solved

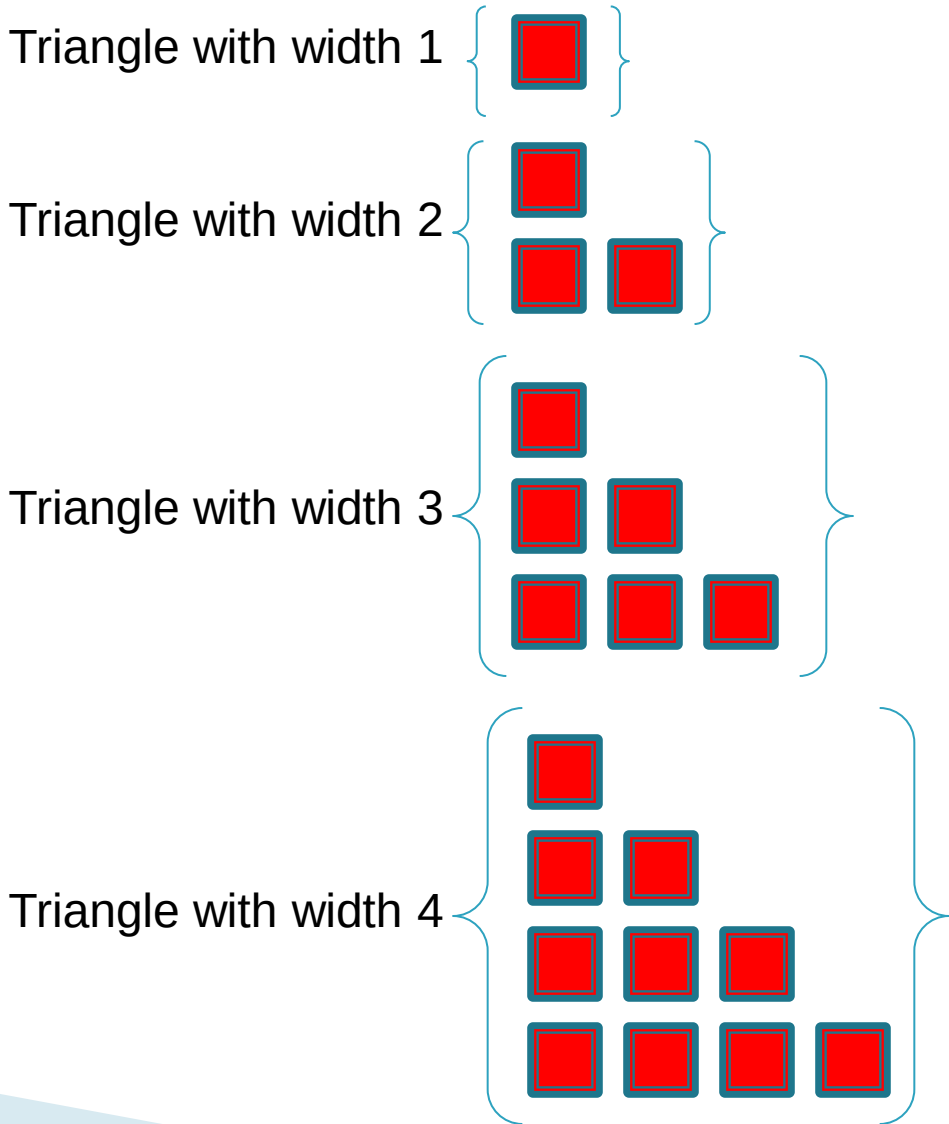
recurs



An example – Triangle Numbers

- If each red block has area 1, what is the ***area*** **A(n)** of the Triangle whose *width* is n?
  - Answer:

    $A(n) = n + A(n-1)$
- The above holds for which *n*? What is the answer for other *n*?
  - Answer: The recursive equation holds for $n >= 1$.
    For $n = 0$, the area is 0.

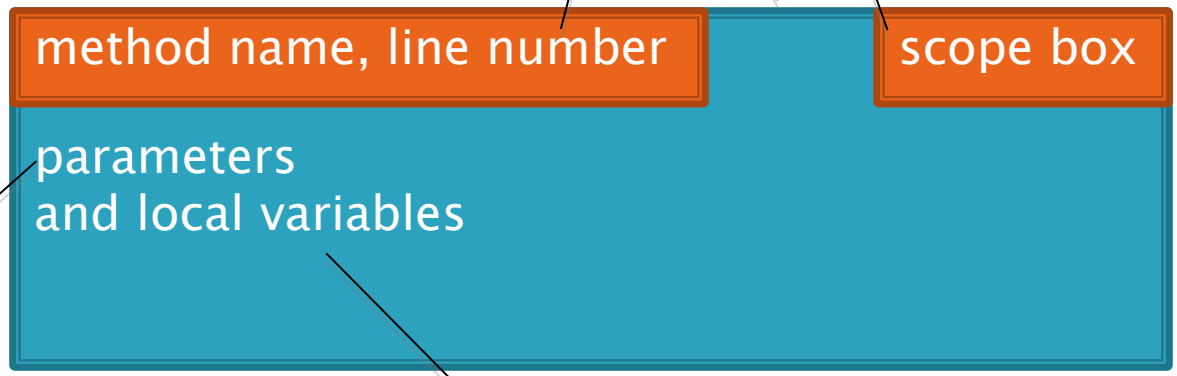


Frames for Tracing Recursive Code

1. Draw box when method starts

2. Fill in name and first line no.

3. Write class name (for static method) or draw reference to object (for non-static method)



4. List every parameter and its argument value.

5. List every local variable declared in the method, **but no values yet**

6. Step through the method, update the line number and variable values, draw new frame for new calls

7. "Erase" the frame when the method is done.

Thanks to David Gries for this technique

Q1-Q2

Optional Practice

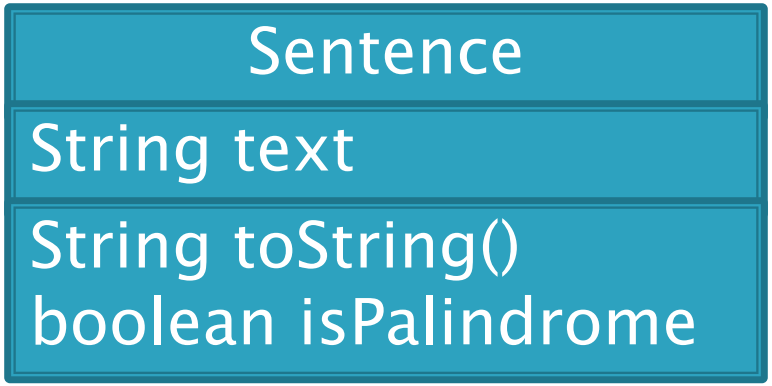
- Trace the **buildShape(MAX_DEPTH)** method call in **shapes.Main**'s **main** method

Key Rules to Using Recursion

- Always have a **base case** that **doesn't recurse**
- Make sure recursive case always **makes progress**, by **solving a smaller problem**
- **You gotta believe**
  - Trust in the recursive solution
  - Just consider one step at a time

Programming Problem

- Add a recursive method to Sentence for computing whether Sentence is a palindrome



Recursive Helpers

- Our isPalindrome() makes lots of new Sentence objects

- We can make it better with a "recursive helper method"
  - Many recursive problems require a helper method

```
public boolean isPalindrome() {
    return isPalindrome(0,  this.text.length() - 1);
}
```

Position of first letter of the remaining String to check

Position of last letter of the remaining String to check

Homework part 1

- Reverse a string…recursively!
- A recursive helper can make this really short!

Another Definition of Recursion

- "If you already know what recursion is, just remember the answer. Otherwise, find someone who is standing closer to Douglas Hofstadter than you are; then ask him or her what recursion is."

  —Andrew Plotkin

Practice Practice Practice

- Head to http://codingbat.com/java/Recursion-1 and solve 5 problems. I personally like bunnyEars, bunnyEars2, count7, fibonacci, and noX
- Get help from me if you get stuck
- Then take a look at the recursion homework (due tomorrow midnight)

Recursive Functions

- Factorial:

$$n! = \begin{cases} 1 & \text{if } n \leq 1 \\ n * (n-1)! & \text{otherwise} \end{cases}$$

Base Case

Recursive step

- Ackermann function:

$$A(m,n) = \begin{cases} n+1 & \text{if } m = 0 \\ A(m-1,1) & \text{if } m > 0 \text{ and } n = 0 \\ A(m-1, A(m,n-1)) & \text{otherwise} \end{cases}$$