Recursion

Ch 14

Announcements

Midterm graded on gradescope

Highlights

- recursion

```cpp
int main()
{
    cout << "HI\n!";
    main();
}
```

Recursion

No fancy blue words or classes this chapter

Recursion is simply calling a method from inside itself

This copy will re-run the method on any new arguments or information

(See: badRecursion.cpp)

Click to exit presentation...

Recursion

If you forget your stopping case, you will not get an infinite loop but crash the program

This is because every function call takes up more memory, so you constantly ask for more memory

Eventually the memory (stack) cannot store anymore

Your mother is so fat,

the recursive function computing her mass causes a stack overflow.

Recursion basics

Good recursion must have 2 parts:
   - A recursive call on a **smaller** problem
   - An ending case

(see: https://www.youtube.com/watch?v=-xMYvVr9fd4)

In order to use recursion, you must be able to identify a subproblem that is very similar to the original problem

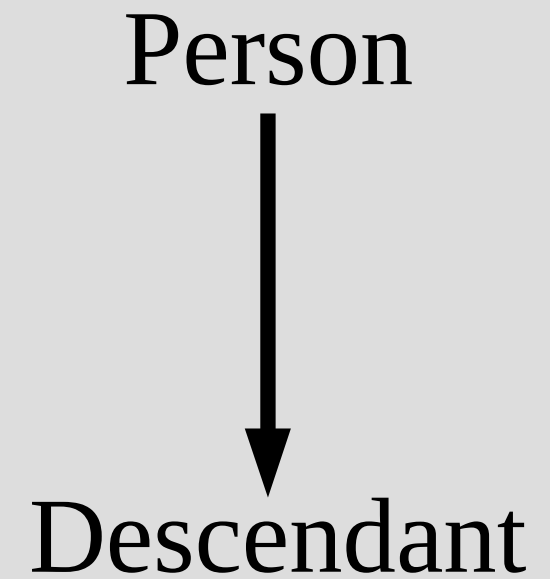Each step must get you closer to the solution

Recursion basics

For recursion, you can basically **assume** your function works as you want it to (even though you have not written it)

If you have the ending case and reduction step correct, then it will!

Magic!

Recursion: Family tree

Person

↓

Descendant

Recursion: In words

A child couldn't sleep, so her mother told
a story about a little frog,
   who couldn't sleep, so the frog's mother told
   a story about a little bear,
      who couldn't sleep, so bear's mother told
      a story about a little weasel
         ...who fell asleep.
      ...and the little bear fell asleep;
   ...and the little frog fell asleep;
...and the child fell asleep. (See: story.cpp)

Recursion: Basic example

Remember, code starts in main and runs from top to bottom in sequence (normally)

When you call a function you go execute all the function's code is run before going back to the original code

Code order is important in recursion!

(See: stringRecursion.cpp)

Recursion

What if I wanted to just count down to zero?
countdown(5) would show:
5
4
3
2
1
0!

(see: countdown.cpp)

Recursion

There are two important parts of recursion:
   -A <u>stopping</u> case that ends the recursion
   -A <u>reduction</u> case that reduces the problem

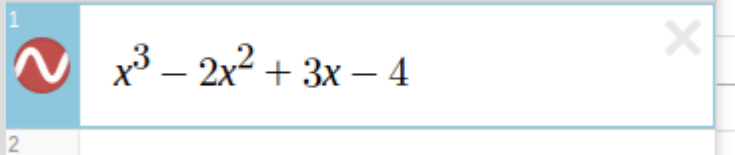What are the base and stopping cases for the Fibonacci numbers?

$$F_n = F_{n-1} + F_{n-2},$$

$$0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, \dots$$

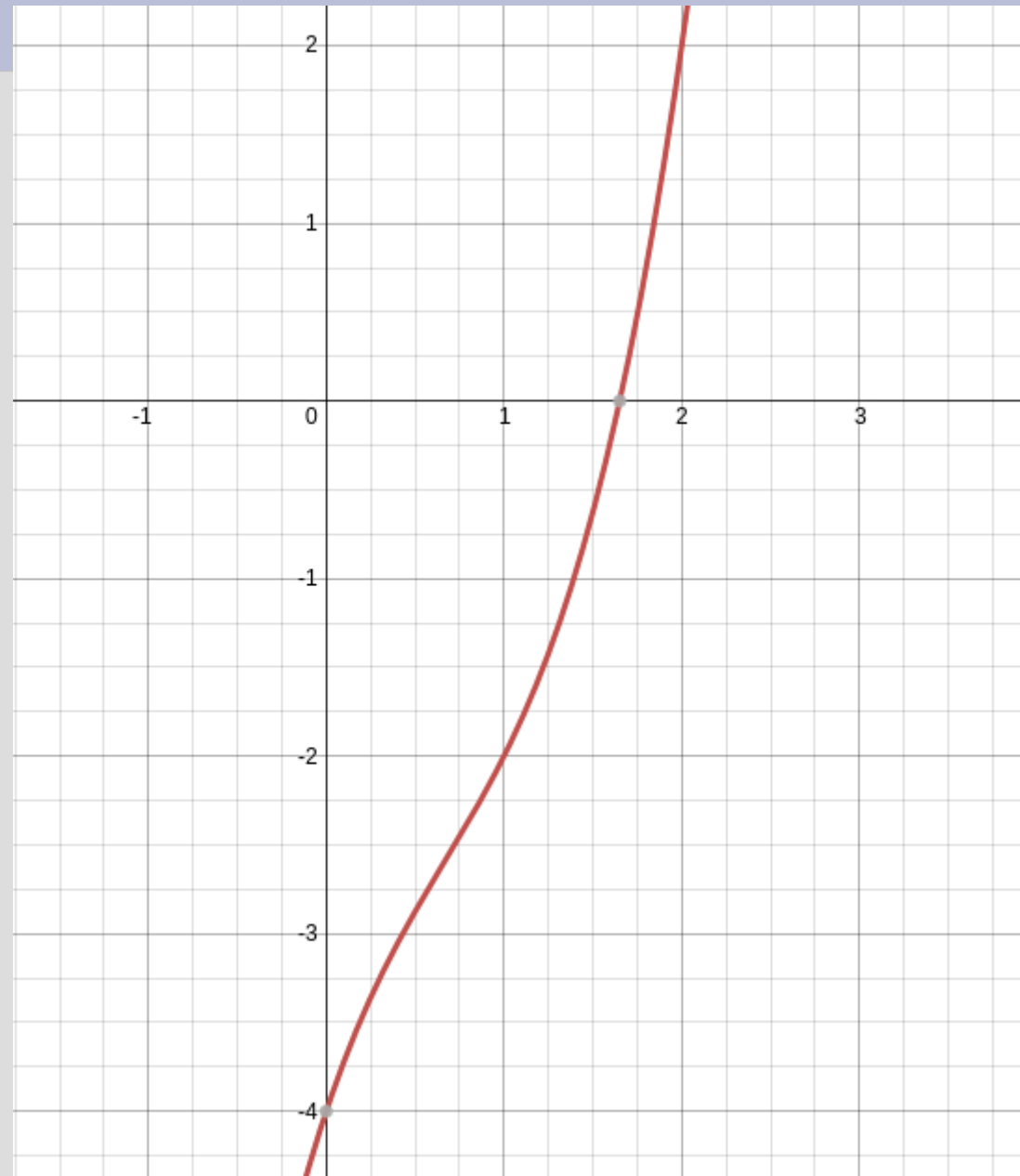   (sum of the previous two numbers)
(see last time: fibonacciRecursion.cpp)

Recursion: Root finding

Find a root of:
(see: rootFind.cpp)

$$x^3 - 2x^2 + 3x - 4$$

Method:
1. Find one positive y and 1 neg. y
2. Find midpoint (of x values)
3. update y-pos/neg

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In order to understand recursion,

you must understand recursion.

Recursion

How would you sum the numbers 1 to n using recursion (not a loop)?

For example sumToN(5) = 15,
as 1+2+3+4+5 = 15

What is the stopping case?
How do you reduce the problem?

(see: sumToN.cpp)

Recursion

What if we defined tangent recursively as:

$$tan(x) = \cfrac{x}{1 - \cfrac{x^2}{3 - \cfrac{x^2}{5 - \cfrac{x^2}{7 - \dots}}}}$$
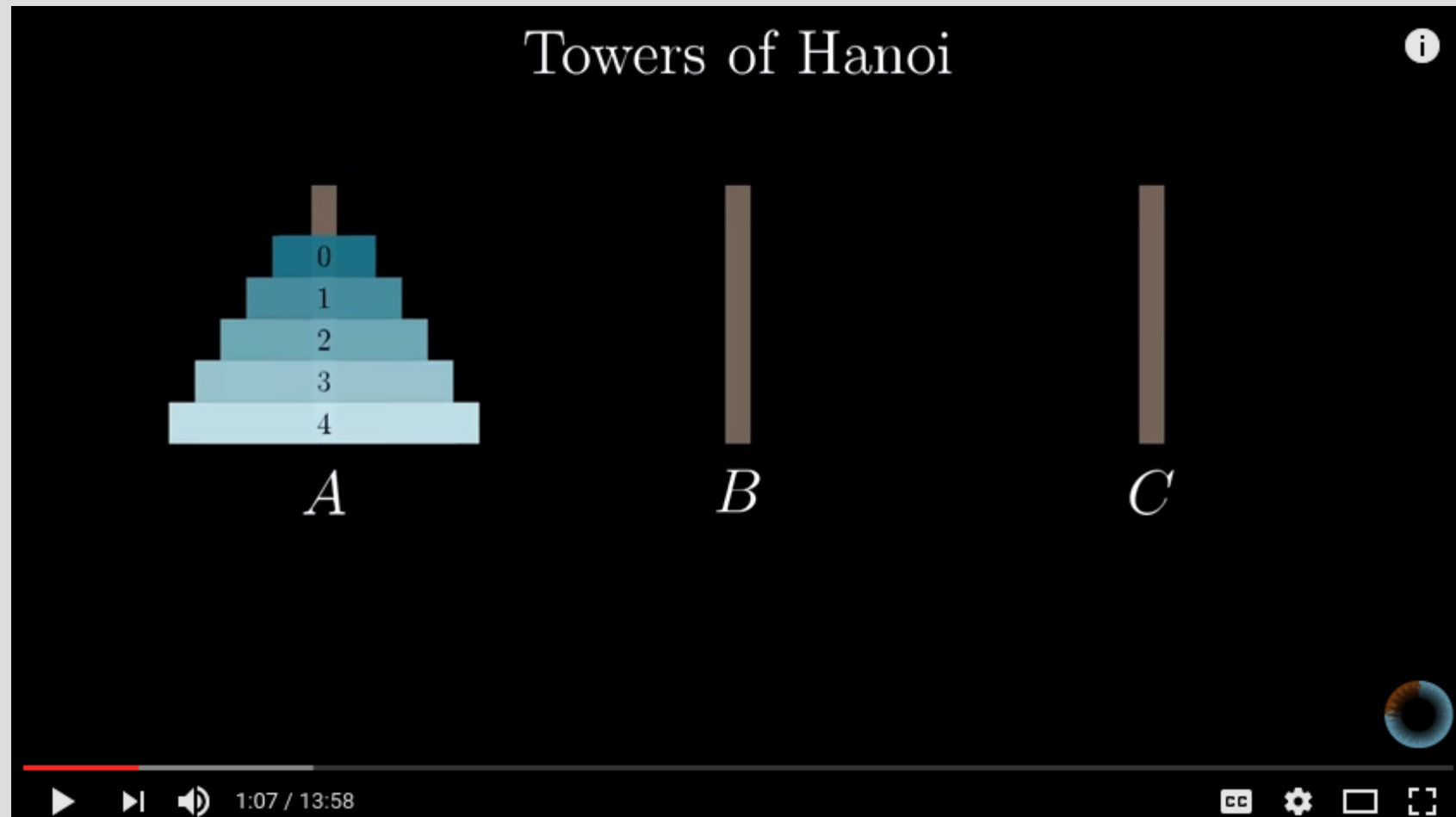
Assume we take an input for how many times to do this recursion

What is the pattern? What is the stopping case?

How do we move towards the stopping case

(see: tangent.cpp)

Recursion: Tower or Hanoi

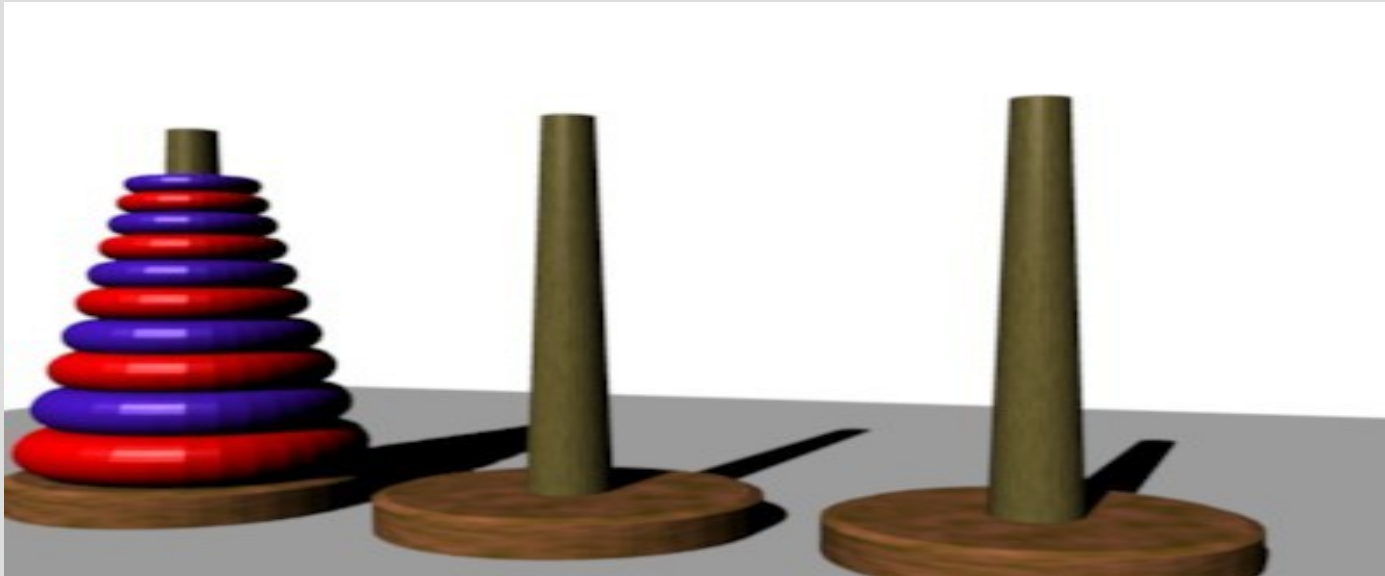https://www.youtube.com/watch?v=2SUvWfNJSsM

Recursion: Tower or Hanoi

The tower of Hanoi is played by:
1. Moving a single ring to another stack
2. Smaller rings cannot have larger rings on top of them

(see: towerHanoi.cpp)

Recursion

How would you solve a sudoku problem?
Rules:
1. Every row has numbers 1-9
2. Every column has numbers 1-9
3. The nine 3x3 boxes have numbers 1-9

Reduce problem?
Stopping case?

(see: sudokuSolver.cpp)

Recursion

Do not try to solve chess in this manner!

You will segfault
(you will also not finish computing before the sun burns the earth to a crisp)

Miscellaneous notes

Try googling "recursion" and click on the spelling suggestion

Recursion is very powerful and used in many advanced algorithms

It will give you a headache for a while...
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