CS 106B, Lecture 9
Recursive Data

Plan for Today

- More recursion practice!
- Learning goals for today
  - See examples of recursively structured data.

Recap: Recursion Tips

- Look for *self-similarity*
- Make the problem *simpler* by doing the least amount of work possible
- *Trust* the recursion
- Find a stopping point (*base case*)

reverseLines exercise

- Write a recursive function `reverseLines` that accepts a file input stream and prints the lines of that file in reverse order.
  - Example input file:

```
Roses are red,
Violets are blue.
All my base
Are belong to you.
```


Expected console output:

```
Are belong to you.
All my base
Violets are blue.
Roses are red,
```

Reversal pseudocode

- Reversing the lines of a file:
  - Read a line L from the file.
  - Print the rest of the lines in reverse order.
  - Print the line L.

- If only we had a way to reverse the rest of the lines of the file....

reverseLines solution

```
void reverseLines(ifstream& input) {
    string line;
    if (getline(input, line)) {
        // recursive case
        reverseLines(input);
        cout << line << endl;
    }
}
```

- Where is the base case?

Stanford C++ files

```
#include "filelib.h"
```

Function	Description
`createDirectory(`***name***`)`	creates a a new directory with given path name
`deleteFile(`***name***`)`	removes file from disk
`fileExists(`***name***`)`	whether this file exists on the disk
`getCurrentDirectory()`	returns directory the current C++ program runs in
`getExtension(`***name***`)`	returns file's extension, e.g. `"foo.cpp"` → `".cpp"`
`getHead(`***name***`)`, `getTail(`***name***`)`	separate a file path into the directory and file part; for `"a/b/c/d.txt"`, head is `"a/b/c"`, tail is `"d.txt"`
`isDirectory(`***name***`)`	returns whether this file name represents a directory
`isFile(`***name***`)`	returns whether this file name represents a regular file
`listDirectory(`***name***`)`	returns a `Vector<string>` with the names of all files contained in the given directory
`readEntireFile(`***name, v***`)`	reads lines of the given file into a vector of strings
`renameFile(`***old, new***`)`	changes a file's name

crawl exercise

- Write a function `crawl` accepts a file name as a parameter and prints information about that file.
  - If the name represents a normal file, just print its name.
  - If the name represents a directory, print its name and information about every file/directory inside it, indented.

```
course
    handouts
        syllabus.doc
        lecture-schedule.xls
    homework
        1-gameoflife
            life.cpp
            life.h
            GameOfLife.pro
```

  - **recursive data**: A directory can contain other directories.

Optional parameters

- We cannot vary the indentation without an extra parameter:

```
void crawl(string filename, string indent) {
```

- Often the parameters we need for our recursion do not match those the client will want to pass.

  One solution is to use a *default parameter* value:

```
void crawl(string filename, string indent = "");
```

  - The client can call `crawl` passing only one parameter.
  - The recursive calls can pass the second parameter to indent.

crawl solution

```
// Prints information about this file,
// and (if it is a directory) any files inside it.
void crawl(string filename, string indent = "") {
    cout << indent << getTail(filename) << endl;
    if (isDirectory(filename)) {
        // recursive case; print contained files/dirs
        Vector<string> filelist;
        listDirectory(filename, filelist);
        for (string subfile : filelist) {
            crawl(filename + "/" + subfile,
                  indent + "    ");
        }
    }
}
```

Announcements

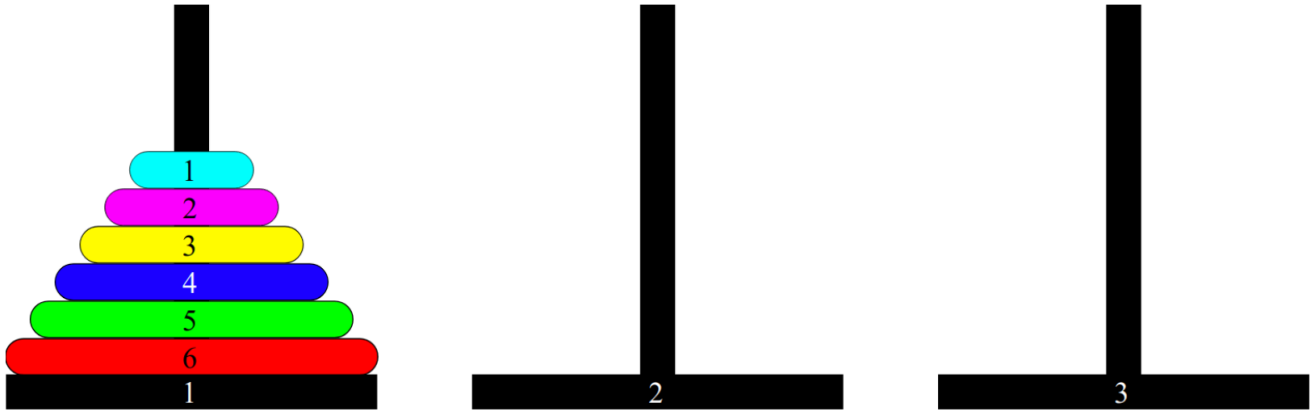
- My OH tomorrow are cancelled ☹
  - Come by today for OH!
  - LaIR is still open tonight and tomorrow
  - Can also post on Piazza for help

- HW2 is due tomorrow at 5PM

Towers of Hanoi

- The Towers of Hanoi puzzle asks a player to move a stack of discs from one peg to another, moving one disc at a time.
  - A disc cannot sit on top of a smaller disc.

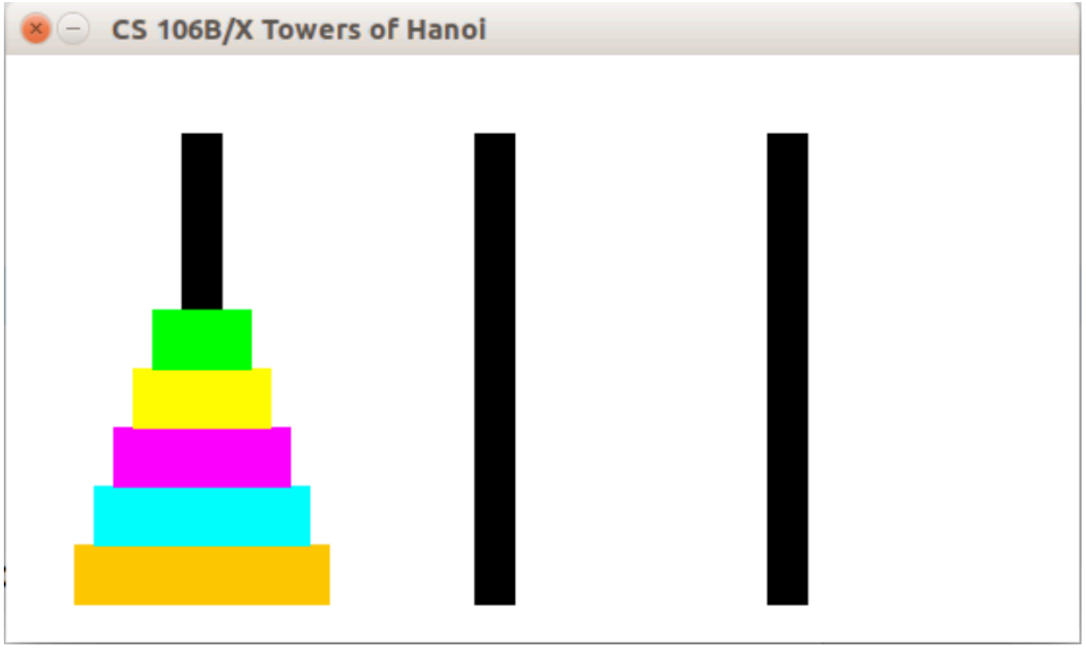
- Write a recursive function moveDiscs with three parameters: number of discs, start peg, end peg, that moves that many discs from the start peg to the end peg.



Towers of Hanoi

- Assume we have a HanoiGui with the following functions:

```
void initialize(int numDiscs)
void moveOneDisc(int startPeg, int endPeg)
int thirdPegNumber(int peg1, int peg2)
```



Hanoi solution

```
// Moves the given number of discs from the given
// starting peg to the given ending peg.
void moveDiscs(int numDiscs, int startPeg, int endPeg) {
  if (numDiscs > 0) {
     // move rest of discs
     int thirdPeg = HanoiGui::thirdPegNumber(startPeg,
           endPeg);
     moveDiscs(numDiscs - 1, startPeg, thirdPeg);
     // move remaining bottom disc
     HanoiGui::moveOneDisc(startPeg, endPeg);
     // move rest of discs
     moveDiscs(numDiscs - 1, thirdPeg, endPeg);
  }
  // else, implicit base case: do nothing
}
```

evenDigits exercise

- Write a recursive function `evenDigits` that accepts an integer and returns a new number containing only the even digits, in the same order. If there are no even digits, return 0.
  - Example: `evenDigits(8342116)` returns `8426`
  - Example: `evenDigits(40109)` returns `400`
  - Example: `evenDigits(8)` returns `8`
  - Example: `evenDigits(-163505)` returns `-60`
  - Example: `evenDigits(35179)` returns `0`

evenDigits solution

```
// Returns a new integer containing only the even-valued
// digits from the given integer, in the same order.
// Returns 0 if there are no even digits.
int evenDigits(int n) {
    if (n < 0) {
        return -evenDigits(-n);
    } else if (n == 0) {
        return 0;
    } else if (n % 2 == 0) {
        return 10 * evenDigits(n / 10) + n % 10;
    } else {
        return evenDigits(n / 10);
    }
}
```