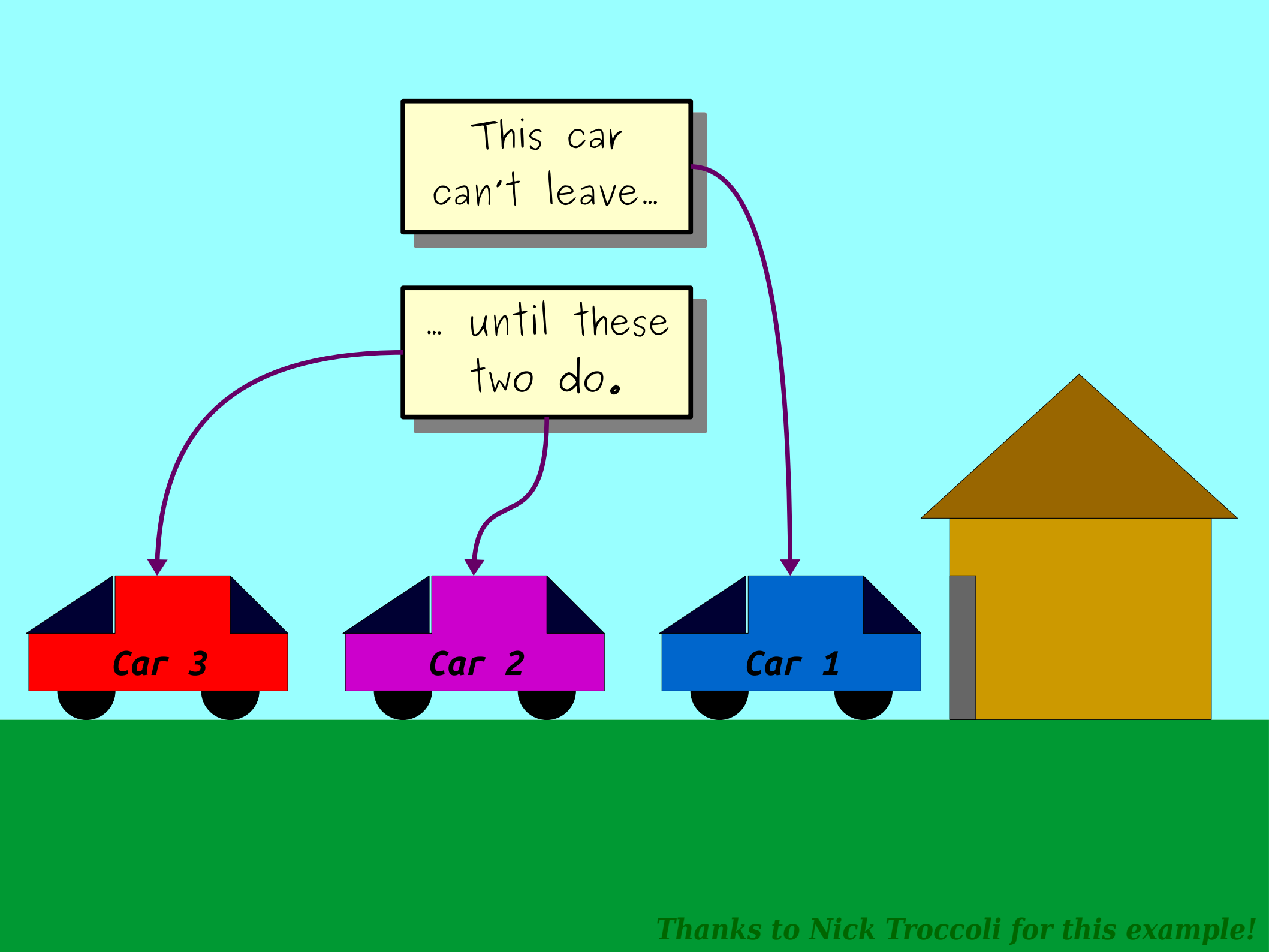
Containers

Part Three

Outline for Today

- ***Stacks***
  - Pancakes meets parsing!
- ***Queues***
  - Playing some music!

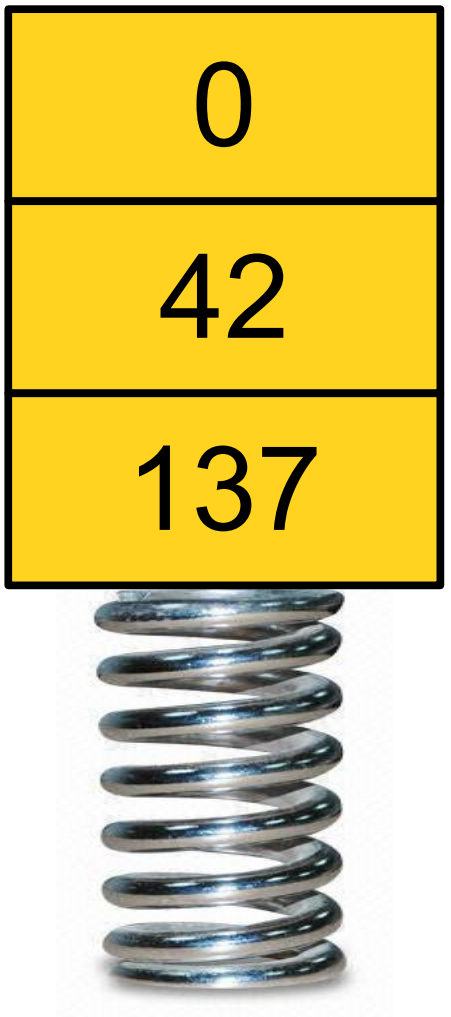
Stack



Thanks to Nick Troccoli for this example!

Stack

- A **`Stack`** is a data structure representing a stack of things.
- Objects can be ***pushed*** on top of the stack or ***popped*** from the top of the stack.
- Only the topmost element of a `Stack` can be accessed.
- Do you see why we call it the *call stack* and talk about *stack frames*?



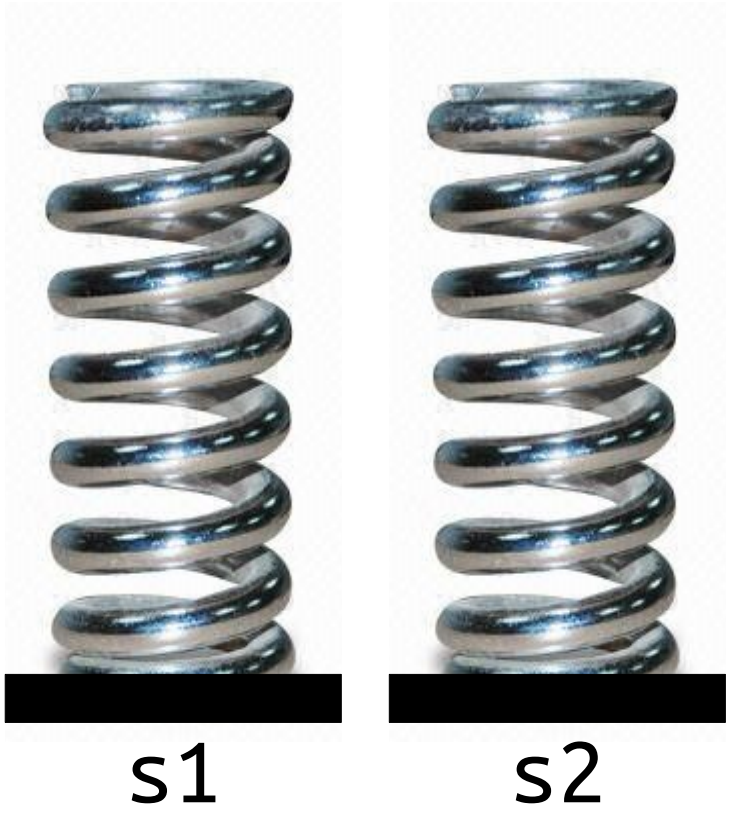
Stack

What does this code print?

```
Stack<char> s1, s2;
s1.push('a');
s1.push('b');
s1.push('c');

while (!s1.isEmpty()) {
  s2.push(s1.pop());
}

while (!s2.isEmpty()) {
  cout << s2.pop() << endl;
}
```



'a'	'b'	'c'

Stack

- Technically speaking, anything you can do with a `Stack` you can also do with a `Vector`.
- So why do we have the `Stack` type as well?
  - ***Clarity:*** Many problems can be modeled elegantly using a stack. Representing those stacks in code with a `Stack` makes the code easier to understand.
  - ***Error-Prevention:*** The `Stack` has fewer operations than a `Vector`. If you're trying to model a stack, this automatically eliminates a large class of errors.
  - ***Efficiency:*** `Stacks` can be slightly faster than `Vectors` because they don't need to support as many operations. (More on that later in the quarter.)

An Application: ***Balanced Parentheses***

Our Algorithm

- For each character:
  - If it’s an open parenthesis or brace, push it onto the stack.
  - If it’s a close parenthesis or brace:
    - If the stack is empty, report an error.
    - If the character doesn’t pair with the character on top of the stack, report an error.
- At the end, return whether the stack is empty (nothing was left unmatched).

More `Stack` Applications

- Stacks show up all the time in ***parsing***, recovering the structure in a piece of text.
  - Often used in natural language processing; take CS224N for details!
  - Used all the time in compilers – take CS143 for details!
  - There's a deep theorem that says that many structures appearing in natural language are perfectly modeled by operations on stacks; come talk to me after class if you're curious!
- They're also used as building blocks in larger algorithms for doing things like
  - making sure a city's road networks are navigable (finding *strongly connected components;* take CS161 for details!) and
  - searching for the best solution to a problem – stay tuned!

Time-Out for Announcements!

MLK Weekend

- Some suggested reading / listening / watching recommendations:
  - “The Autobiography of Malcolm X,” as told to Alex Haley.
  - “The Ballot or the Bullet” by Malcolm X.
  - “Between the World and Me” by Ta-Nehisi Coates.
  - “The Case for Reparations” by Ta-Nehisi Coates.
  - “Debate at Cambridge Union,” James Baldwin and William F. Buckley, Jr.
  - “Do Artifacts Have Politics?” by Langdon Winner.
  - “Letter from Birmingham City Jail” by Martin Luther King, Jr.
  - “Letter from a Region in my Mind” by James Baldwin.
  - “Notes on an Imagined Plaque” by The Memory Palace.
  - “The Other America” by Martin Luther King, Jr.

Asynchronous Lecture

- We will not have class this upcoming Monday in observance of the MLK holiday.
- Monday’s lecture will instead be prerecorded and available online on Canvas starting at around 5PM today.
- Watch that lecture before we return for Wednesday’s (in-person) lecture.

Assignment 2

- Assignment 1 was due today a 1:00PM.
  - Need more time? Use one late day to extend the deadline by 24 hours or two to extend it by 48 hours.
- Assignment 2 (***Fun With Collections***) goes out today. It's due next Friday at 1:00PM.
  - Use collections to learn what language a text is written in – and expand your mind about the world of human language!
  - Explore the impact of sea level rise on coastal regions!
- Have questions?
  - Stop by the LaIR! Or ask on EdStem! Or email your section leader!

Assignment 2

- This assignment contains a series of short-answer ethics questions designed to get you thinking about the social impact of computing.
- It’s critical to think about the effect your software has on others, especially given the scale of modern software systems.
- These will form a part of your grade on the assignment separately from your functionality and style scores.

YEAH Hours

- We will be holding YEAH hours on ***Fridays*** from ***4:30PM – 5:30PM***.
- Today’s will be in ***Durand 450***.
- These are purely optional, but are great ways to get an overview of the assignment before you dive into it.
- Sessions will be recorded, and slides will be made available for folks who can’t make it.

Discussion Sections

- Discussion sections have started! You should have received an email with your section time and section leader's name.
- Don't have a section? You can sign up for any open section by visiting

  https://cs198.stanford.edu/

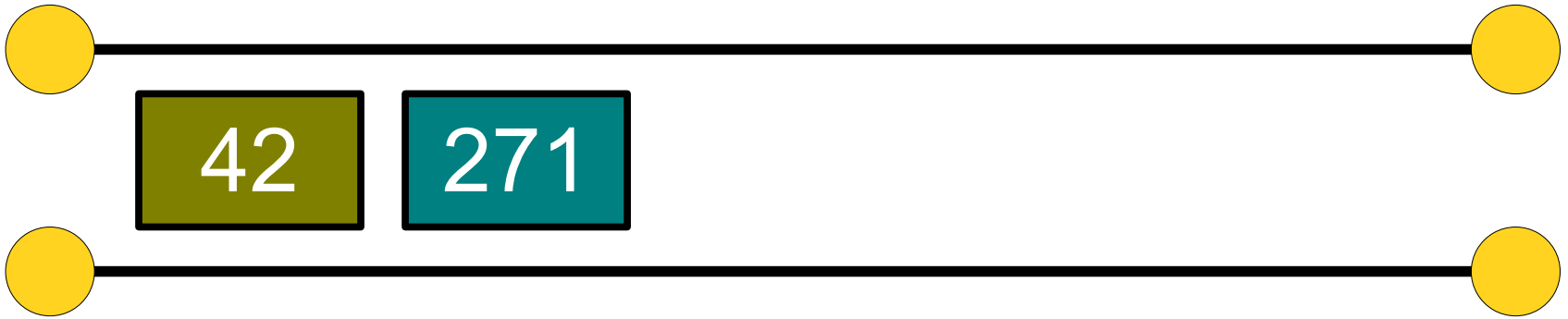
  logging in via "CS106 Sections Login," and picking a section of your choice.
- Attendance is required.
  - If you have a recurring conflict, contact Jonathan to discuss a permanent swap.
  - If you have one-off conflicts, email your section leader at least 24 hours in advance.

```
lecture.pop();
```

Queue

Queue

- A **`Queue`** is a data structure representing a waiting line.
- Objects can be ***enqueued*** to the back of the line or ***dequeued*** from the front of the line.
- No other objects in the queue are visible.
- Example: A checkout counter.



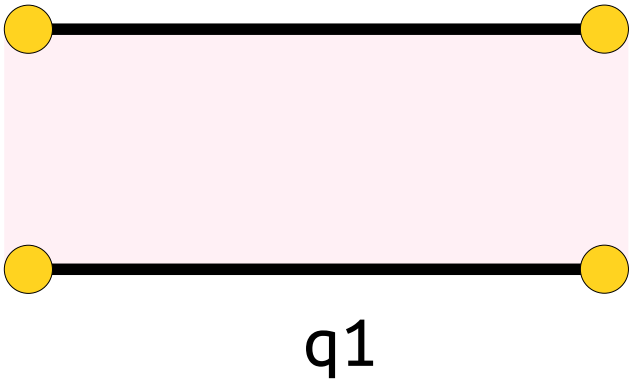
Queue

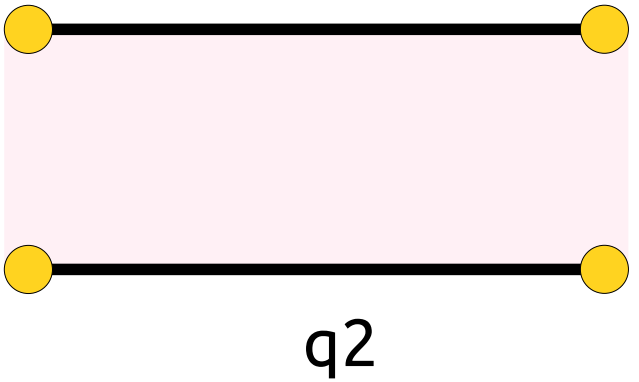
- What does this code print?

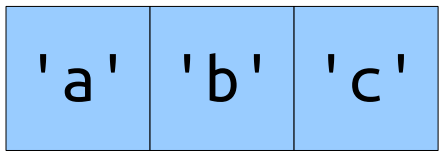
```
Queue<char> q1, q2;
q1.enqueue('a');
q1.enqueue('b');
q1.enqueue('c');

while (!q1.isEmpty()) {
  q2.enqueue(q1.dequeue());
}

while (!q2.isEmpty()) {
  cout << q2.dequeue() << endl;
}
```







An Application: ***Looper***

Loopers

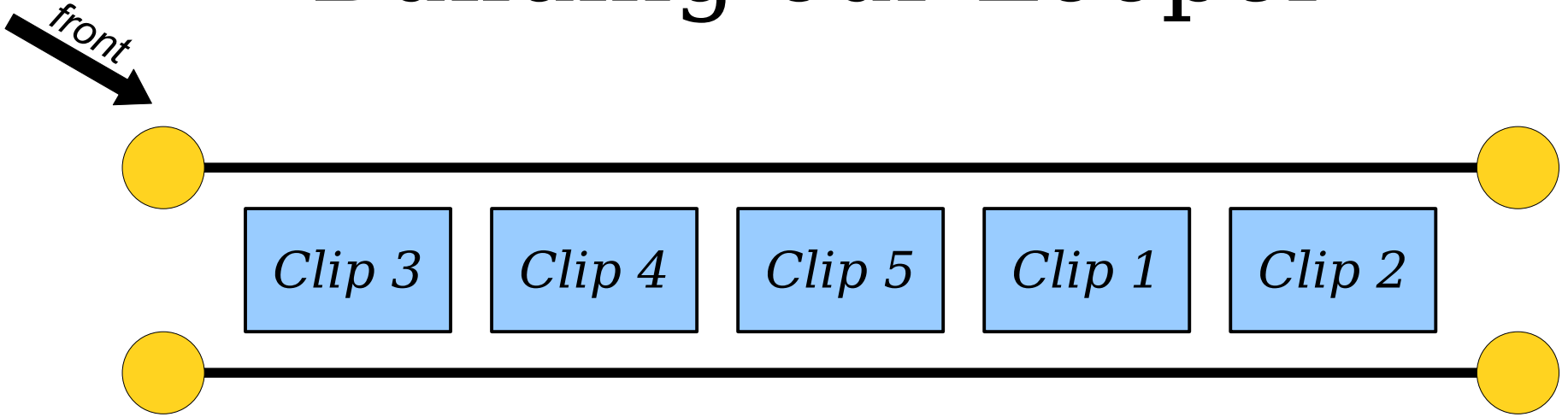
- A ***looper*** is a device that records sound or music, then plays it back over and over again (in a loop).
- These things are way too much fun, *especially* if you're not a very good musician.
- Let's make a simple looper using a `Queue`.

Building our Looper

- Our looper will read data files like the one shown to the left.
- Each line consists of the name of a sound file to play, along with how many milliseconds to play that sound for.
- We'll store each line using the `SoundClip` type, which is defined in our C++ file.

```
G2.wav 690
G2.wav 230
Bb2.wav 230
G2.wav 460
G2.wav 460
G2.wav 460
G2.wav 230
Bb2.wav 230
G2.wav 230
F2.wav 460
```

Building our Looper




```
Queue<SoundClip> loop = loadLoop(/* … */);
while (true) {
  SoundClip toPlay = loop.dequeue();
  playSound(toPlay.filename, toPlay.length);

  loop.enqueue(toPlay);
}
```

Enjoying Our Looper

Feeling musical? Want to contribute a loop for the next iteration of CS106B? Send me your .loop file and we'll add it to our collection!

Changing our Looper

What are you going to hear when we use this version of the looper?

Answer at
https://cs106b.stanford.edu/pollev

```
Stack<SoundClip> loop = loadLoop(/* … */);
while (true) {
  SoundClip toPlay = loop.pop();
  playSound(toPlay.filename, toPlay.length);

  loop.push(toPlay);
}
```

Your Action Items

- ***Read Chapter 5.2 and 5.3.***
  - These sections cover more about the `Stack` and `Queue` type, and they're great resources to check out.
- ***Start Assignment 2.***
  - To follow our suggested timetable, start working on Rosetta Stone and make good progress on it by Monday.

Next Time (Virtually!)

- ***Thinking Recursively***
  - More elaborate recursive functions.
- ***Recursive Graphics***
  - Drawing intricate and beautiful figures with very little code.