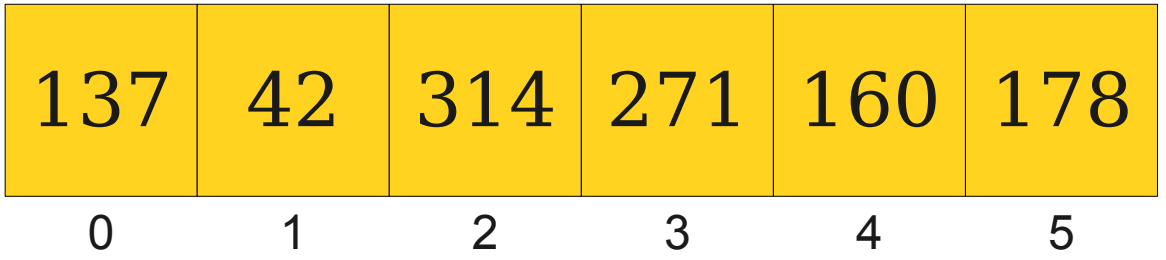
Arrays

Friday Four Square!
Today at 4:15PM, outside Gates.

A Different Way to Store Data

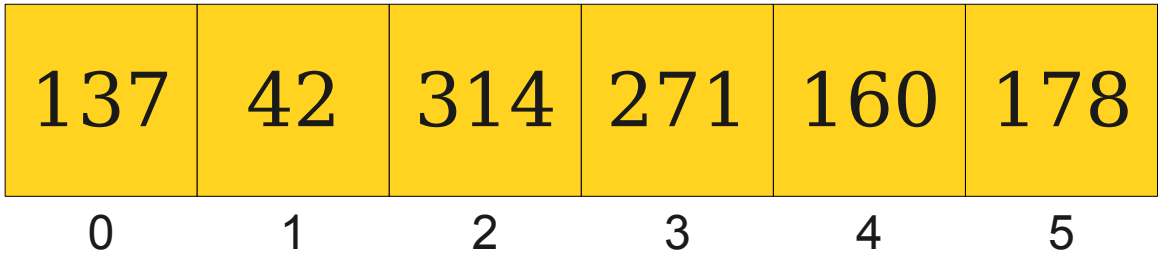
- Last time, we saw the **`ArrayList`** as a way to store lots of data.
  - Lines of text.
  - US cities!
- Java also supports a concept called the **array** that can used to store lots of data.

Recapping `ArrayList`



- An **`ArrayList`** stores a **sequence** of multiple objects.
  - Can access objects by index by calling **`get`**.
- All stored objects have the same type.
  - You get to choose the type!
- Must store objects; primitive types not allowed.
- Can grow as long as it needs.

Introducing Arrays



- An array stores a **sequence** of multiple objects.
  - Can access objects by index using square brackets (more on that soon).
- All stored objects have the same type.
  - You get to choose the type!
- Can store *any* type, even primitive types.
- Size is fixed; cannot grow once created.

Basic Array Operations

- To create a new array, specify the type of the array and the size in the call to **`new`**:

```
Type[] arr = new Type[size]
```

- To access an element of the array, use the square brackets to choose the index:

```
arr[index]
```

- To read the length of an array, you can read the **`length`** field:

```
arr.length
```

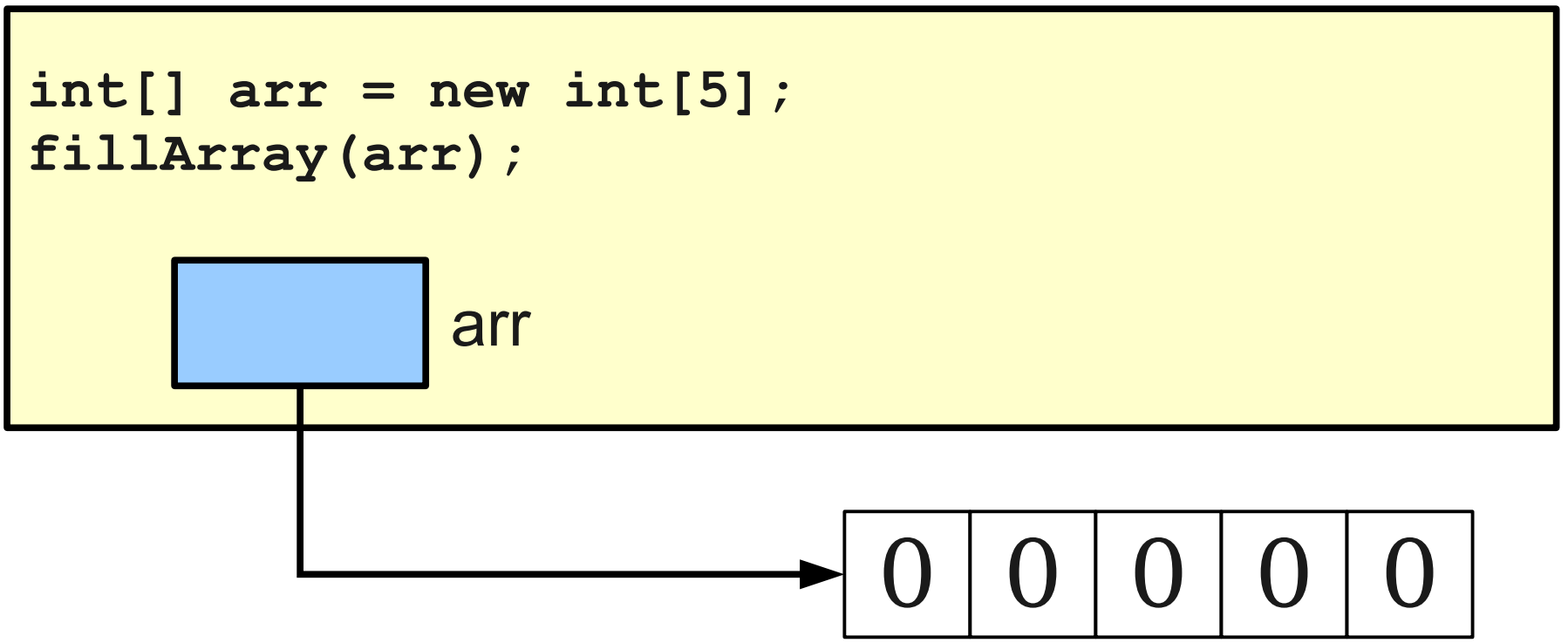
Default Values in Arrays

- When creating an array:
  - `int`, `double`, `char`, etc. default to 0,
  - `boolean` defaults to `false`, and
  - Objects default to `null`.

A Nuance of Pass-by-Reference

- Arrays are objects, so they are passed by reference.
- The **elements** of an array, like the fields of an object, can be modified inside of a method.

```
int[] arr = new int[5];
fillArray(arr);
```



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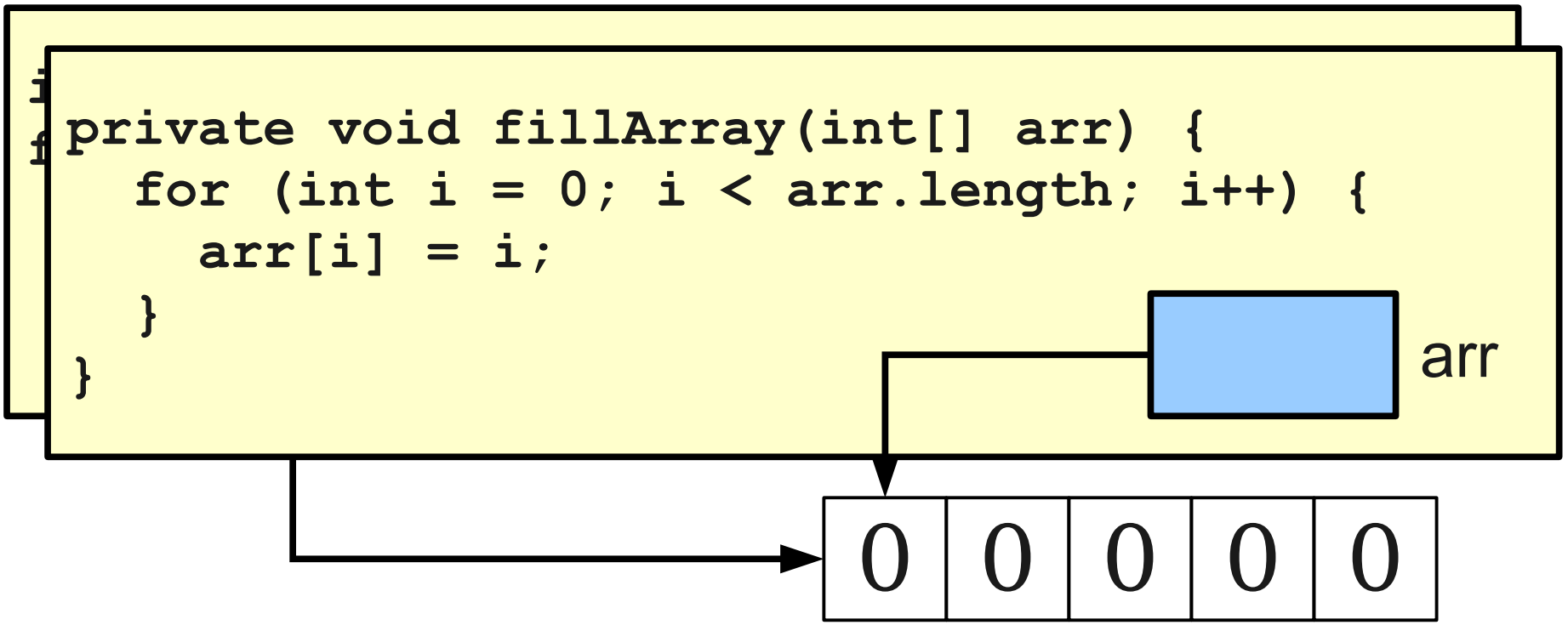

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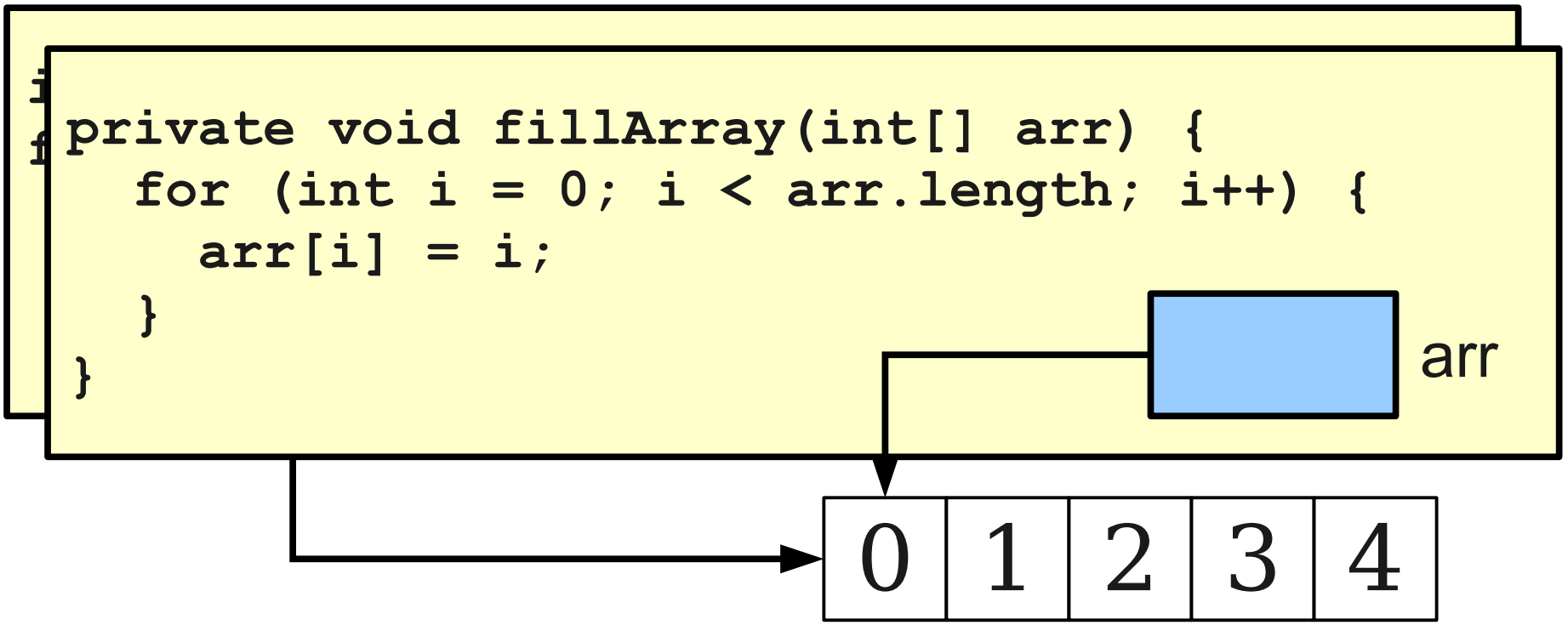

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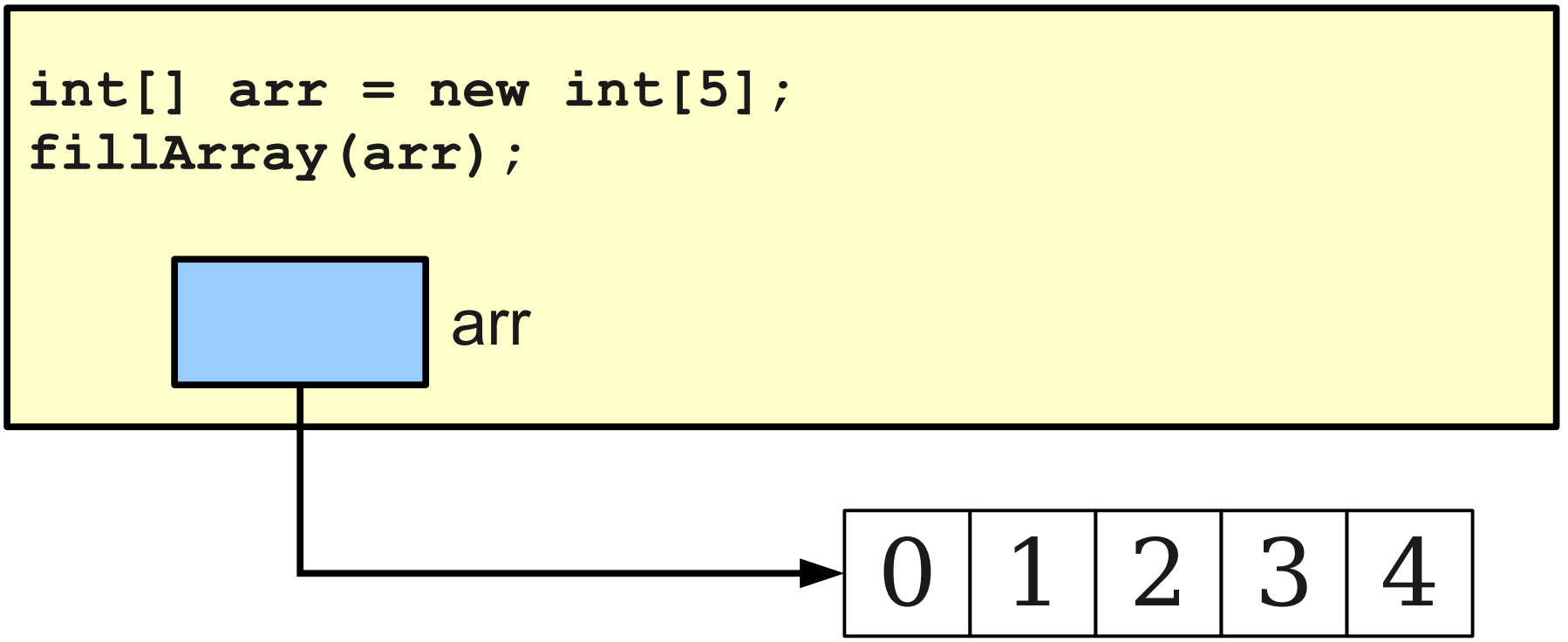
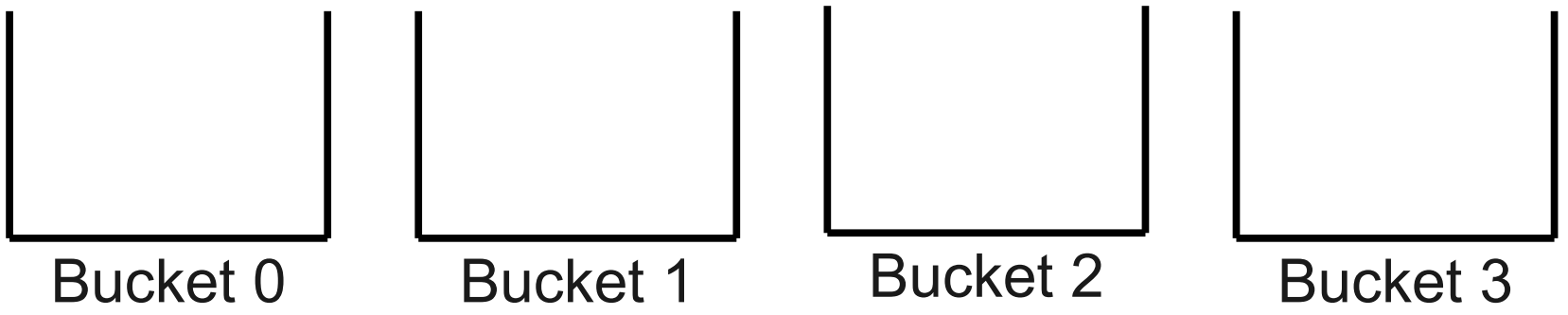


Why Arrays?

- Arrays are excellent for representing a fixed-size list of **buckets**.
- We can store values in the appropriate bucket by looking up the bucket by index.



How many people need to be in a room before two of them will share a birthday?

The Birthday Paradox

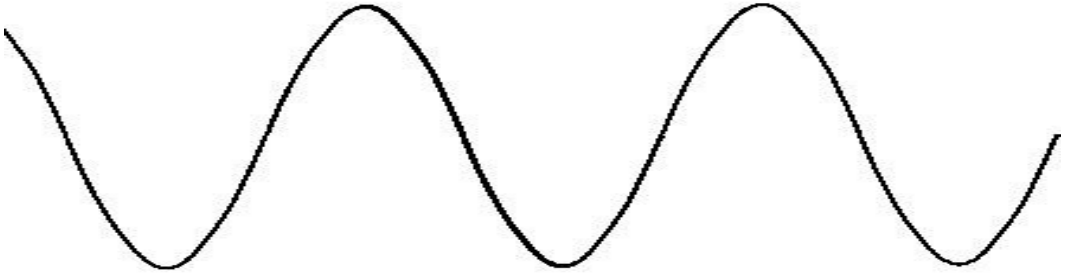
- In a room of 23 people, there is a 50% chance that two of them have the same birthday.
- More generally, if you have an n-sided die, you only need to roll it around $\sqrt{2n}$ times before you have a 50% chance of getting the same outcome twice.

How many people do you need, on average, for three people to share a birthday?

Sound Processing

The Physics of Sound

- Sound is a wave that propagates through a medium.



The **frequency** of the wave is how closely packed together the peaks are.

  - Corresponds to **pitch**.

- The **amplitude** of the wave is how tall the peaks are.

  - Corresponds to **loudness**.

Representing Sound

- The computer can represent a sound by storing the sound wave.

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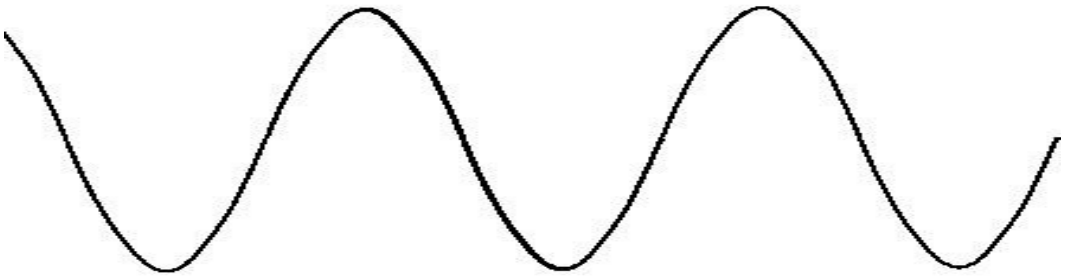

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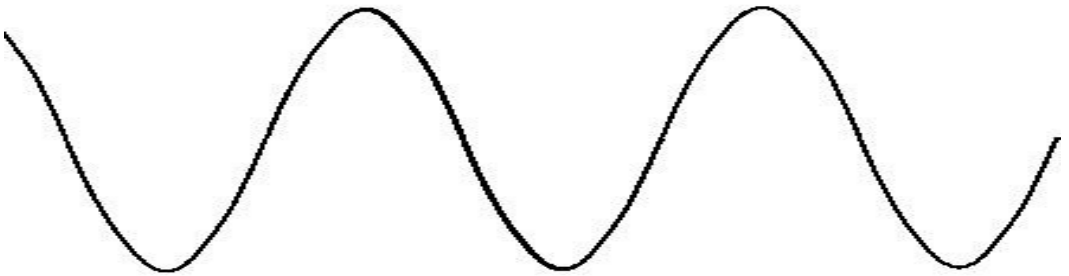

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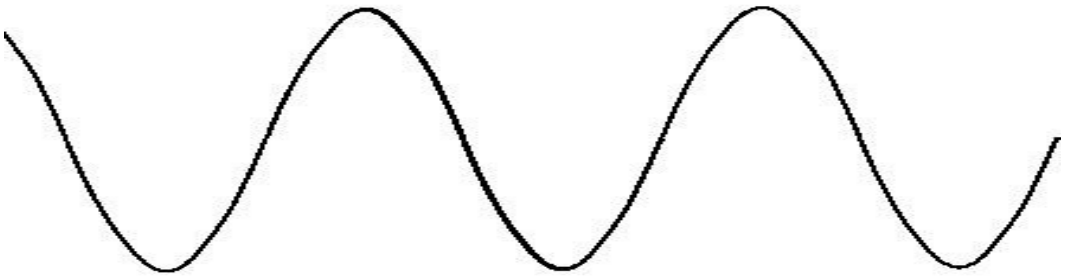

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- **Idea:** Sample points from the sound wave and store those instead.

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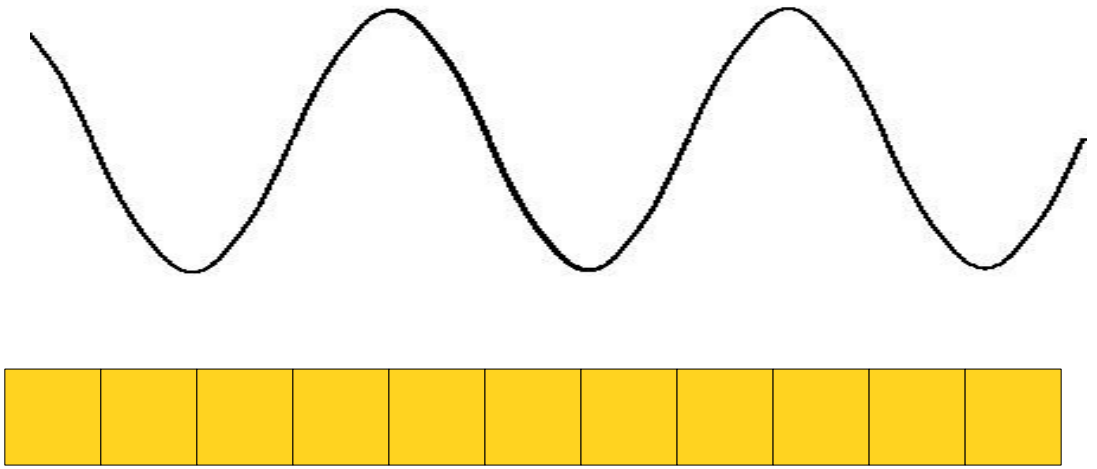

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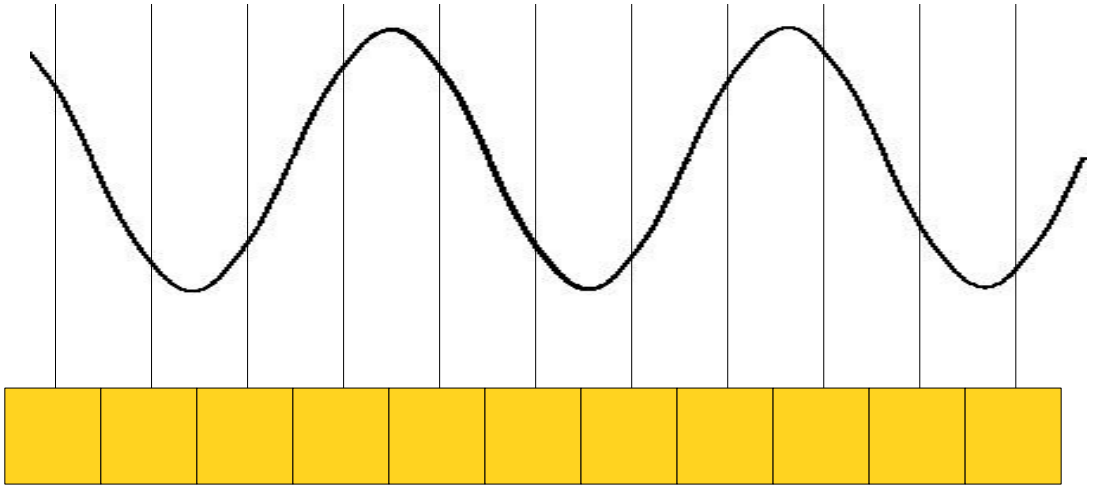

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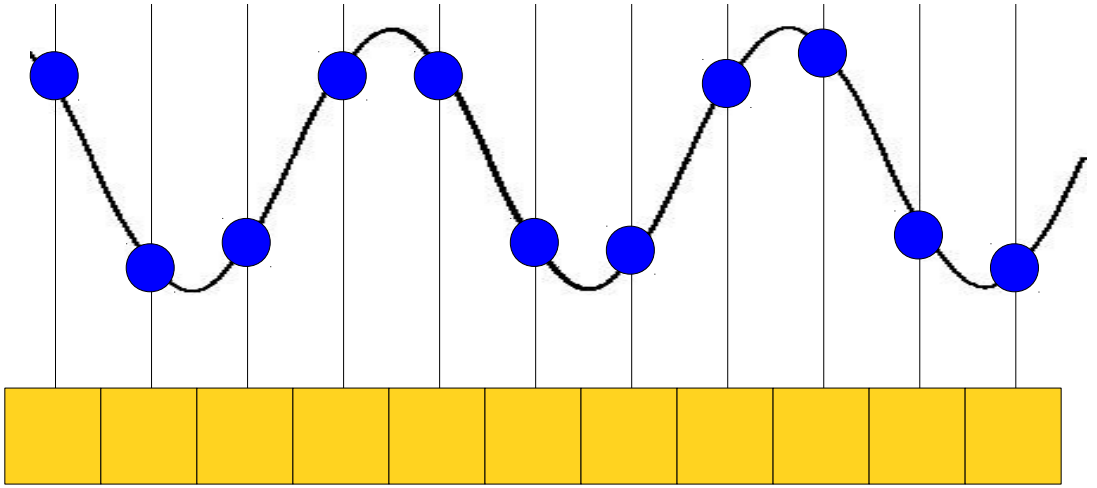

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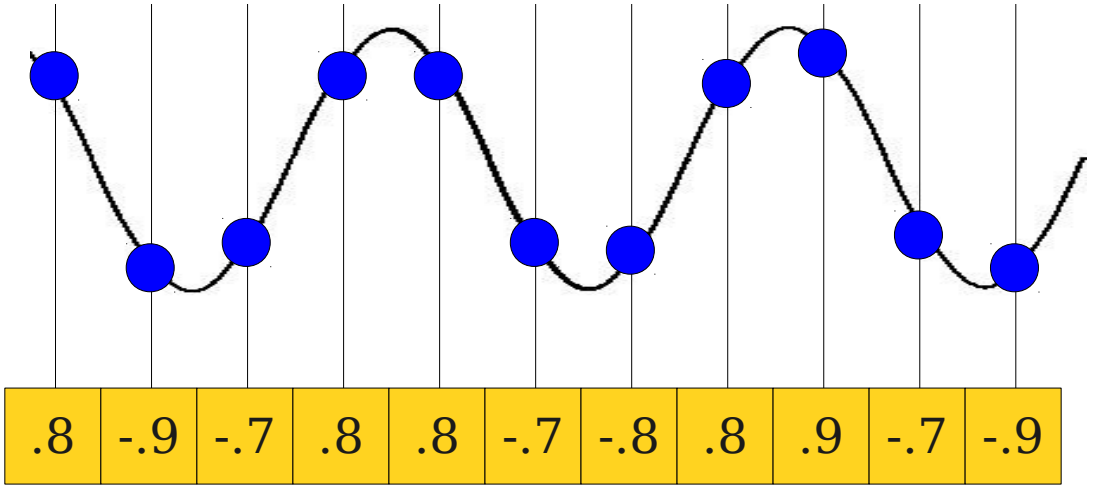

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The Sampling Rate

- The **sampling rate** for a sound clip is the frequency at which the wave's intensity is recorded.
  - Measured in hertz (Hz).
- Example: If sampling rate is 44,100Hz, there are 44,100 samples per second.
- High sampling rate makes for better sound.
- Low sampling rate uses less storage space.

Generating Sound

- Today, we'll use Princeton's **`StdAudio`** class to play sounds.
- Each sound clip is represented as a **`double[]`**, where each entry is between -1 and +1.
- We can play the sound by calling

```
StdAudio.play(soundClip)
```

Creating a Sine Wave

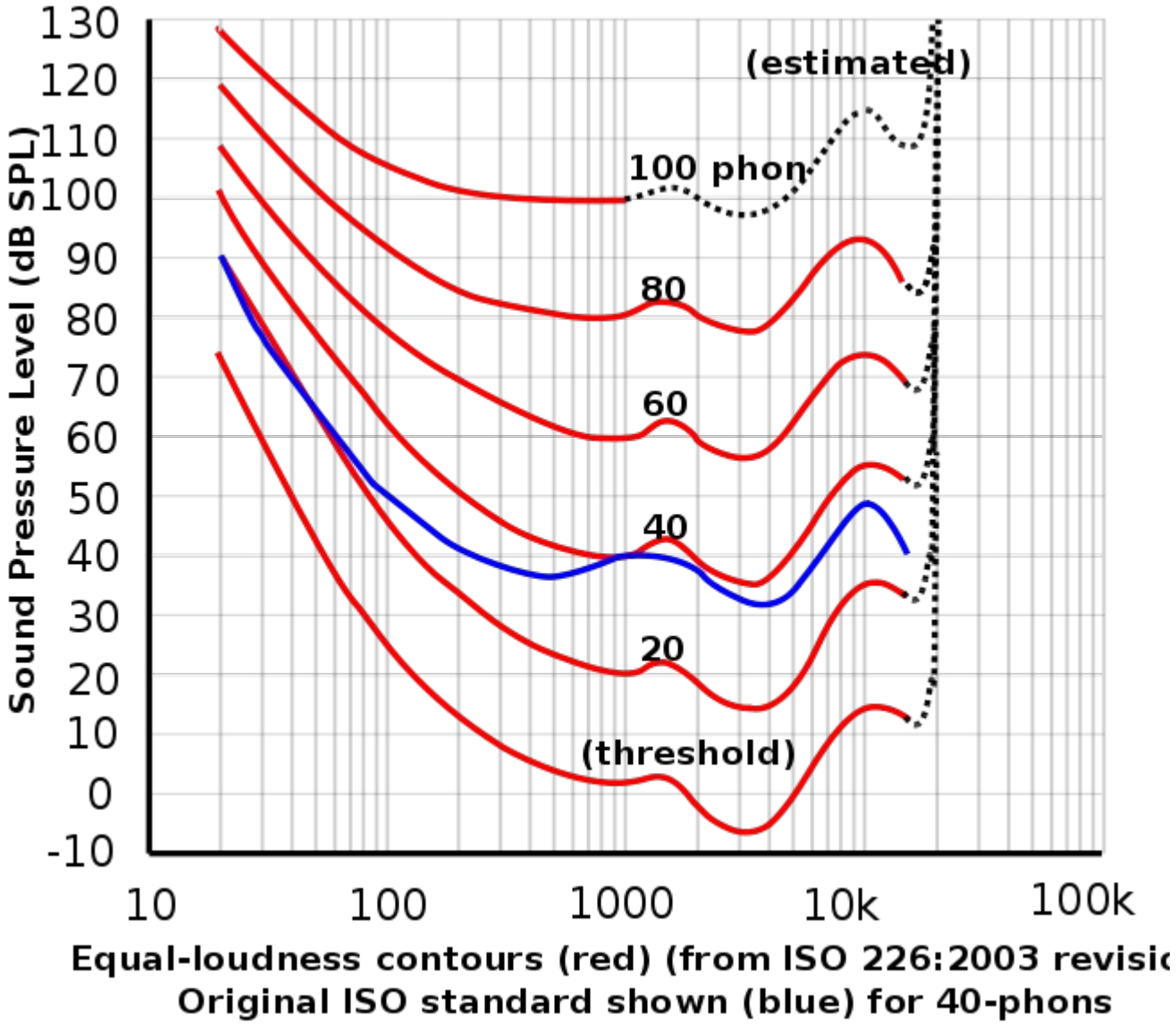
- To make a sine wave with frequency *f*, we want to sample from the wave

$$\sin\left(2\pi x f\right)$$

- However, since time is scaled by the sampling rate, the wave we want is

$$\sin\left(\frac{2\pi x f}{\text{SAMPLING\_RATE}}\right)$$

Equal-Loudness Contours



Source: http://en.wikipedia.org/wiki/File:Lindos1.svg

Loading Sound

- The **`StdAudio`** class also has a function for loading sound from a **`.wav`** file:

```
double[] sound = StdAudio.read(filename)
```

- Requires the sound file to use 44.1KHz sampling rate.