2D Arrays & Images
Introduction

- Images are 2D arrays of Pixels
- Pixels are integers values between 0 and 255
Loading an Image into a 2D array

```java
int[][] img = ImageData.load("myImage.jpeg");
```

- `ImageData` is a library for reading an image into a 2D array of `int` values.
- `load()` takes the name of a file containing an image and returns an `int[][][]`
  - Can you guess how many `rows` are in the output array? How many `columns`?
Contents of the 2D array

```java
int[][] img = ImageData.load("myImage.jpeg");
```

- Returns a `int[][]` with dimensions that match the input image:
  - `img.length` is the number of rows & the vertical height of the image
  - `img[0].length` is the number of columns & the horizontal width of the image

Each pixel is represented as an `int` in `img`. The `int` values represent the alpha, red, green, and blue values of each color.

When expanded into a *binary string*, the `int` (a whole 32-bit number) looks like this:

```
11100010110000110011001111101101
```
Contents of the 2D array

```java
int[][] img = ImageData.load('myImage.jpeg');
```

Each pixel is represented as an `int` in `img`. The `int` values represent the alpha, red, green, and blue values of each color.

If we break the 32-bit number into 4 groups of 8 bits and convert the values to decimal, we can see the values (0-255) for each color:

<table>
<thead>
<tr>
<th></th>
<th>alpha</th>
<th>red</th>
<th>green</th>
<th>blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>binary</td>
<td>11100010</td>
<td>11000011</td>
<td>00110011</td>
<td>11101101</td>
</tr>
<tr>
<td>decimal</td>
<td>226</td>
<td>195</td>
<td>51</td>
<td>237</td>
</tr>
</tbody>
</table>

This text is written in the color represented by the above int.
Contents of the 2D array

You don’t have to worry about the math, but given an int representing a pixel, then:

```java
int red = ImageManipulator.getRed(pixel); // given a pixel, get the red value
int green = ImageManipulator.getGreen(pixel); // get the green value
int blue = ImageManipulator.getBlue(pixel); // get the blue value

// turn a number between 0–255 into a full 32 bit grayscale color.
int fullGray = ImageManipulator.toGrayscaleRGB(intensity);
```
Display an Image

ImageData.show() takes in an int[][] and displays it as an image.

```java
int[][] img = new int[300][300];
for (int i = 0; i < 300; i++) {
    for (int j = 0; j < 300; j++) {
        int grayColor = (int) (255 * Math.sqrt(i * i + j * j) / 425);
        img[i][j] = ImageManipulator.toGrayscaleRGB(grayColor);
    }
}
ImageData.show(img);
```
Image Manipulations

Black and White

- Load the image as an `int[][][]`
- Create a new `int[][][]` of the same dimensions to copy into
- For each pixel, calculate its average intensity: average of the red, green, and blue values
- Use this intensity to calculate the grayscale value of the pixel and copy into output array
Image Manipulations

Vertical Flip

- Load the image as an `int[][]`
- Create a new `int[][]` of the same dimensions to copy into
- For each `row` in the image, copy the row into the new 2D in reverse order
Image Manipulations

Vertical Flip

- Given a rectangular int[][] representing an image, create a new int 2D array with the same dimensions.
- The orders of the rows in the new array should be reversed.
- The values within the rows should have the same order, but row 0 should be row \((n-1)\) in the flipped array, row 1 should be row \((n-2)\), and so on.