Topics

- Graphics and Images
- Coordinate System
- Representing Color
- Drawing Shapes
- Scalable Drawings
- Simple Animation
A picture or drawing must be digitized for storage on a computer.

A picture is made up of pixels (picture elements), and each pixel is stored separately.

The picture resolution is the number of pixels used to represent a picture.

The number of pixels that can be displayed on a screen is called the screen resolution.
Images

- A medium resolution image (original image was $1000 \times 563$ pixels).

- The same image zoomed in to show pixels.
Graphics Coordinate System

- Each pixel is identified using a two-dimensional coordinate system.
- In graphics, the origin is at the top left corner with $x$ coordinate increasing to the right and $y$ coordinate increasing going down.
Representing Color

- A black and white picture can be represented with 1 bit per pixel (0 = white, 1 = black). A grayscale picture can be represented with 8 bits per pixel (0-255).
- A colored picture can be represented as a mixture of primary colors Red, Green, and Blue. Each color is represented by three numbers between 0 and 255 that collectively are called an RGB value. How many colors can we represent with the RGB representation?
- In Java, color is represented as a `Color` class (from the `java.awt` package)
  ```java
  Color myColor = new Color(0, 255, 255);
  ```
- Some predefined colors in the `Color` class.

<table>
<thead>
<tr>
<th>Color</th>
<th>Object</th>
<th>RGB value</th>
</tr>
</thead>
<tbody>
<tr>
<td>black</td>
<td>Color.black</td>
<td>0, 0, 0</td>
</tr>
<tr>
<td>white</td>
<td>Color.white</td>
<td>255, 255, 255</td>
</tr>
<tr>
<td>red</td>
<td>Color.red</td>
<td>255, 0, 0</td>
</tr>
<tr>
<td>green</td>
<td>Color.green</td>
<td>0, 255, 0</td>
</tr>
<tr>
<td>blue</td>
<td>Color.blue</td>
<td>0, 0, 255</td>
</tr>
<tr>
<td>yellow</td>
<td>Color.yellow</td>
<td>255, 255, 0</td>
</tr>
<tr>
<td>cyan</td>
<td>Color.cyan</td>
<td>0, 255, 255</td>
</tr>
</tbody>
</table>
We will use the `Graphics` class from the `java.awt` package for drawing shapes.

The `Graphics` class provides methods for drawing lines, rectangles, ovals, arcs and strings among others.

Shapes drawn by the `Graphics` class can be *unfilled* or *filled*.

The method parameters specify coordinates and sizes.

Shapes with curves, like an oval, are usually drawn by specifying the shape’s *bounding rectangle*.

An *arc* is a section of an oval.
Graphics Class (2)

- Selected methods from the Graphics class.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>drawLine(int x1, int y1, int x2, int y2)</code></td>
<td>Draws a line between the points ((x1, y1)) and ((x2, y2))</td>
</tr>
<tr>
<td><code>drawRect(int x, int y, int width, int height)</code></td>
<td>Draws/fills the specified rectangle.</td>
</tr>
<tr>
<td><code>fillRect(int x, int y, int width, int height)</code></td>
<td>Draws/fills the specified rectangle.</td>
</tr>
<tr>
<td><code>drawOval(int x, int y, int width, int height)</code></td>
<td>Draws/fills the oval bounded by the specified rectangle.</td>
</tr>
<tr>
<td><code>fillOval(int x, int y, int width, int height)</code></td>
<td>Draws/fills the oval bounded by the specified rectangle.</td>
</tr>
<tr>
<td><code>drawArc(int x, int y, int width, int height, int startAngle, int arcAngle)</code></td>
<td>Draws/fills the arc bounded by the specified rectangle.</td>
</tr>
<tr>
<td><code>fillArc(int x, int y, int width, int height, int startAngle, int arcAngle)</code></td>
<td>Draws/fills the arc bounded by the specified rectangle.</td>
</tr>
<tr>
<td><code>drawString(String str, int x, int y)</code></td>
<td>Draws the text given by the specified string.</td>
</tr>
<tr>
<td><code>getColor()</code></td>
<td>Gets/sets the current color.</td>
</tr>
<tr>
<td><code>setColor(Color c)</code></td>
<td></td>
</tr>
</tbody>
</table>
Graphics Class (3)

- The `drawRect` method:
  ```java
  page.drawRect(50, 50, 200, 100);
  ```

- The `drawOval` method:
  ```java
  page.drawOval(50, 50, 200, 100);
  ```
The `drawArc` method:

```java
page.drawArc(50, 50, 200, 100, 20, 90);
```
Examples

- We will use a template that extends the `JPanel` class from the `javax.swing` package. Focus only on the `paintComponent` method!

- Examples:
  - `BasicShapes.java`
  - `Shapes.java`
  - `Snowman.java`
  - **In-class Exercise:** Modify the snowman program as follows:
    - Move the sun to the upper right
    - Display your name in the upper left corner of the picture
    - Make the snowman frown instead of smile
    - Shift the entire snowman to the left by 20 pixels
  - **Further Exercise.** Scale the Snowman to half the size!
Graphics Techniques

- Basic techniques for drawing:
  - Translation (Illustrated in the Snowman example using the MID variable)
  - Centering
  - Scaling

- This example illustrates how to make the graphics center and scale automatically if the user resizes the window.
  - DrawPieChart.java
  - DrawPieChartScalable.java

- An example that shows how to use a custom font and center a String using font metrics: CenterText.java

- Another example that shows how to draw thicker lines: Strokes.java

- Another example that shows how to load an image: ImageAvatar.java
Animation involves drawing the picture multiple times (with incremental variation) per second using a timer to create the illusion of movement.

The individual pictures are referred to as frames in movies (animated or otherwise).

These examples show how we can animate our drawings!

- SimpleAnimation.java
- DigitalClock.java
Summary

- How graphics coordinate system works
- How color is represented
- How to center, scale and translate drawings
- How animation works
- Using Graphics, Color, Font and related classes
Exercises

- Read Appendix F (pp. 965–973).
- **Recommended Homework:**
  - Projects: PP F.4, PP F.15.