Computer Programming Fundamentals

CS 152
Professor: Leah Buechley
TAs: Melody Horn, Noah Garcia, Andrew Geyko, Juan Ormaza
Time: MWF 10:00-10:50am
https://handandmachine.cs.unm.edu/classes/CS152_Fall2021/

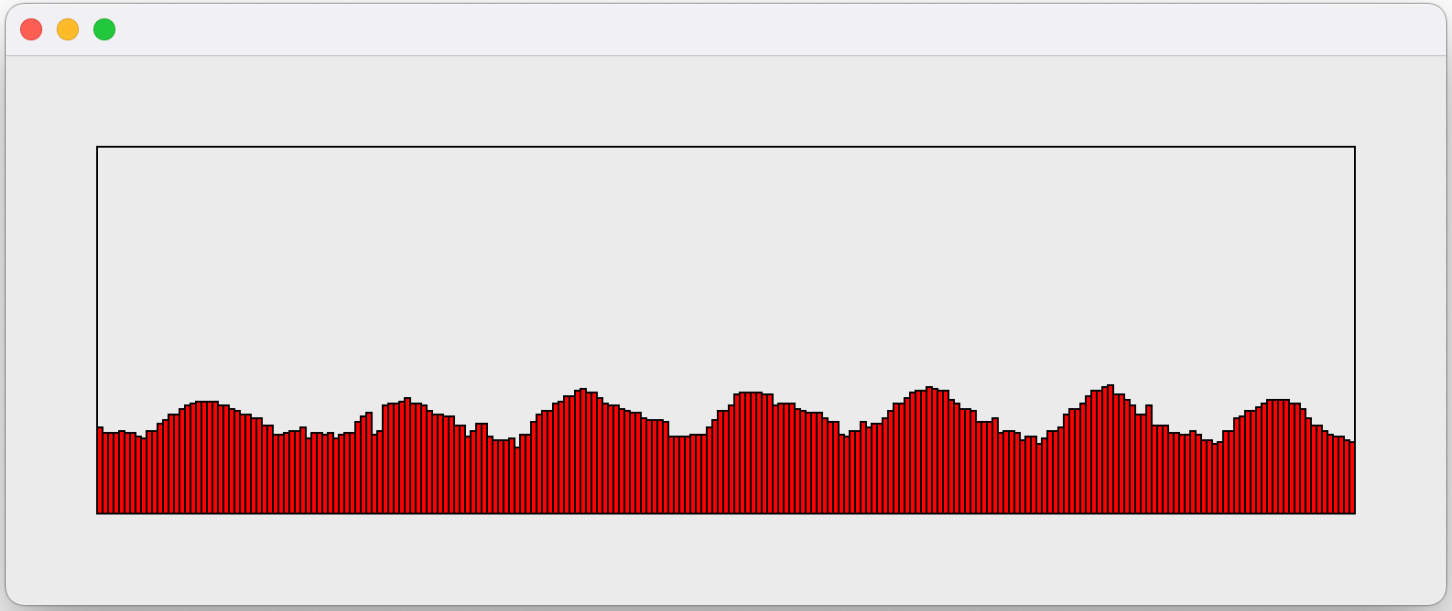
ASSIGNMENT 5 and QUIZ 4 GRADED

ASSIGNMENT 7
POSTED LATER TODAY

FINISH YOUR COURSE EVALUATIONS

WHERE WE ARE

MADE A BAR GRAPH



STARTED TO IMPROVE IT

- ~~Add color~~
- ~~Add space for axes around graph~~
- ~~Draw square around graph area~~
- Draw y axis tic marks to show scale and values
- Draw x axis tic marks to show scale and values
- Draw axis labels
- Draw title

WORKING ON ADDING TIC MARKS

DRAW Y-AXIS TIC MARKS

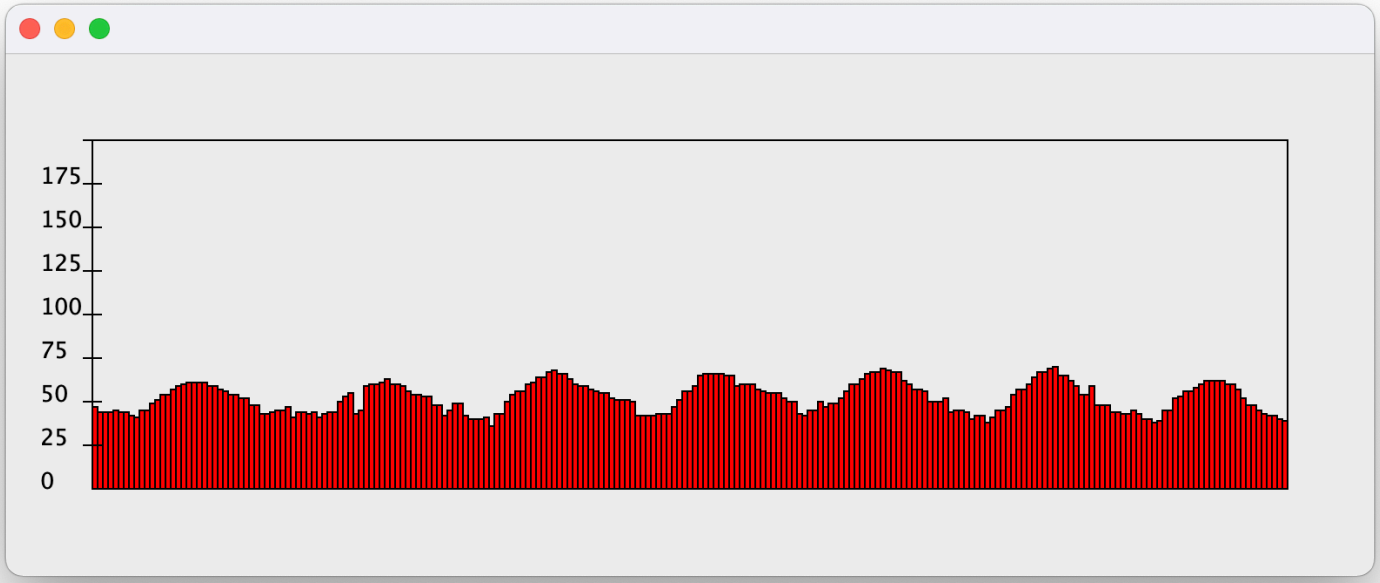
```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0];   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<graphHeight;i=i+25) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
    }
}
```

draw a 10 pixel horizontal line on y axis every 25 pixels

DRAW Y-AXIS LABELS

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0];   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<graphHeight;i=i+25) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i),spacer-30, height-(i+spacer));
    }
}
```

ADD TIC MARKS: Y

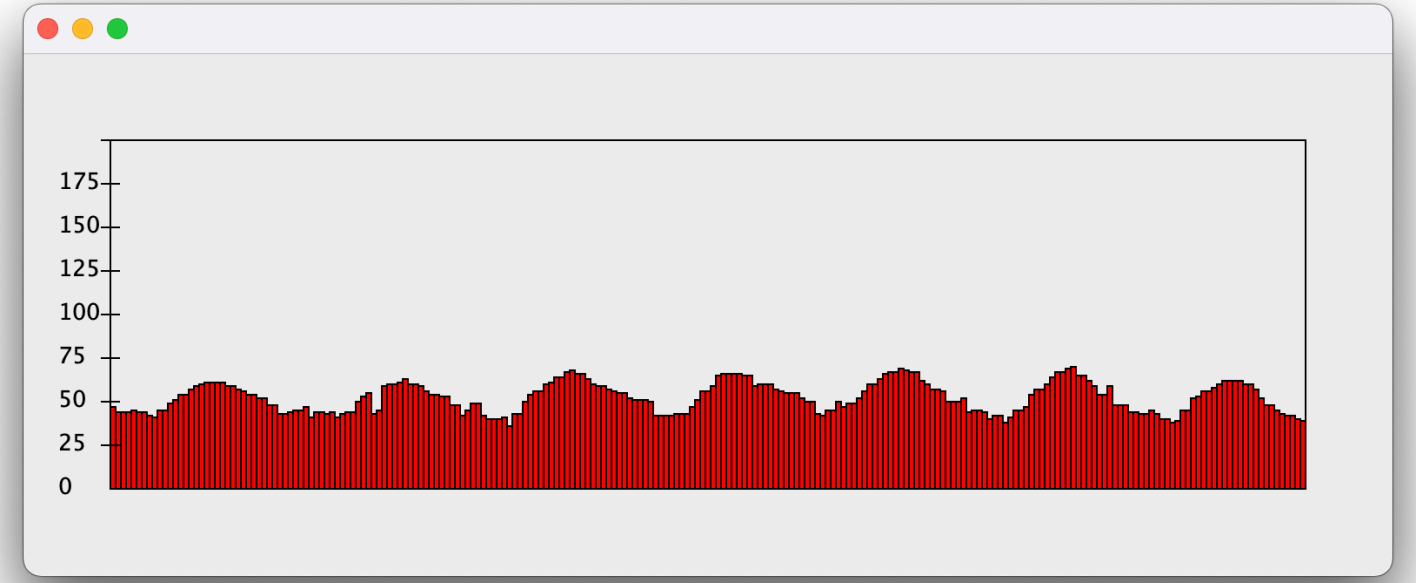


BETTER LABEL POSITIONING

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0];   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<graphHeight;i=i+25) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i),spacer-30, height-(i+spacer)+3);
    }
}
```

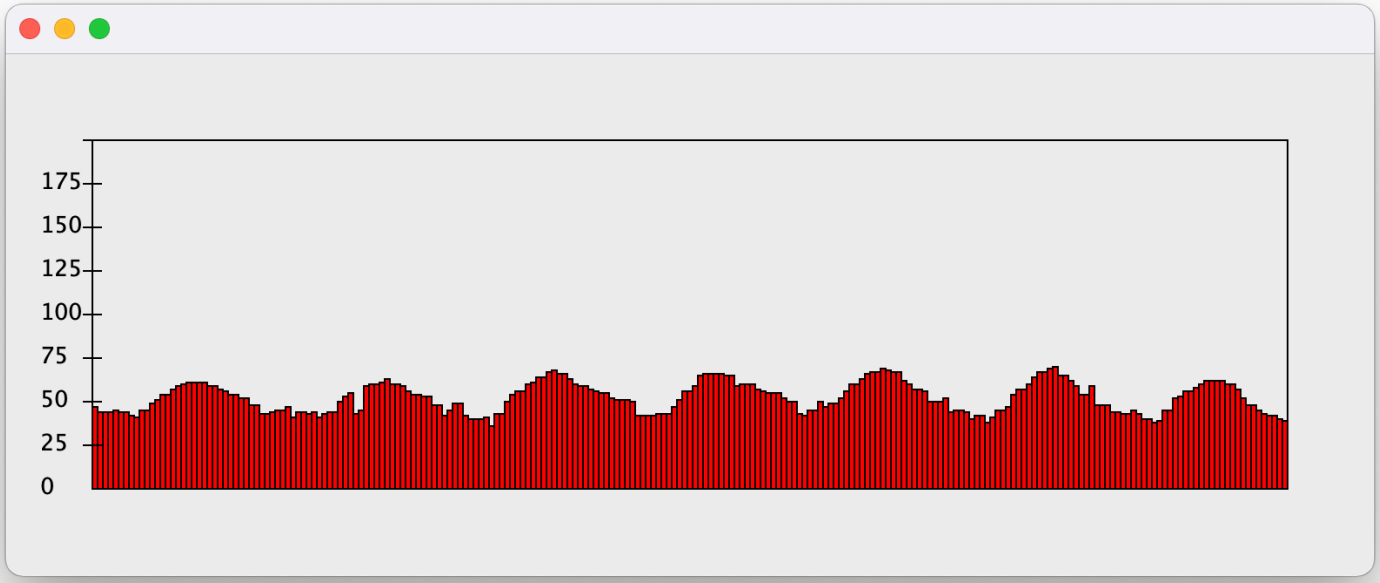
shift numbers down 3 pixels

BETTER LABEL POSITIONING



THINKING ABOUT SCALE

DOES TEMPERATURE REACH 175?



CHANGE Y AXIS SCALE: 0 - 100

How do we do this?

CHANGE Y AXIS SCALE

- Scale rectangle height to fit new range
- Change labels and tic marks to match new range

CHANGE Y AXIS SCALE

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0];   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<graphHeight;i=i+25) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i),spacer-30, height-(i+spacer)+3);
    }
}
```

add variables

CHANGE Y AXIS SCALE

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<graphHeight;i=i+25) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i),spacer-30, height-(i+spacer)+3);
    }
}
```

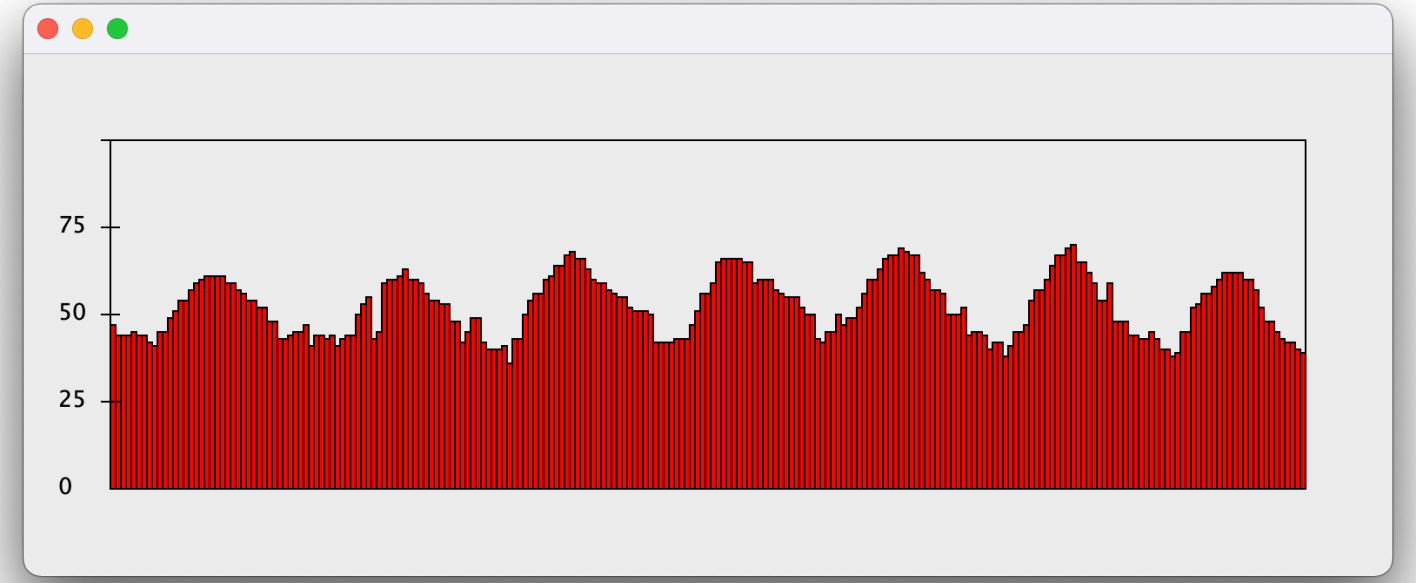
scale rectangle height

CHANGE Y AXIS SCALE

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }
}
```

change labels

CHANGE Y-AXIS SCALE

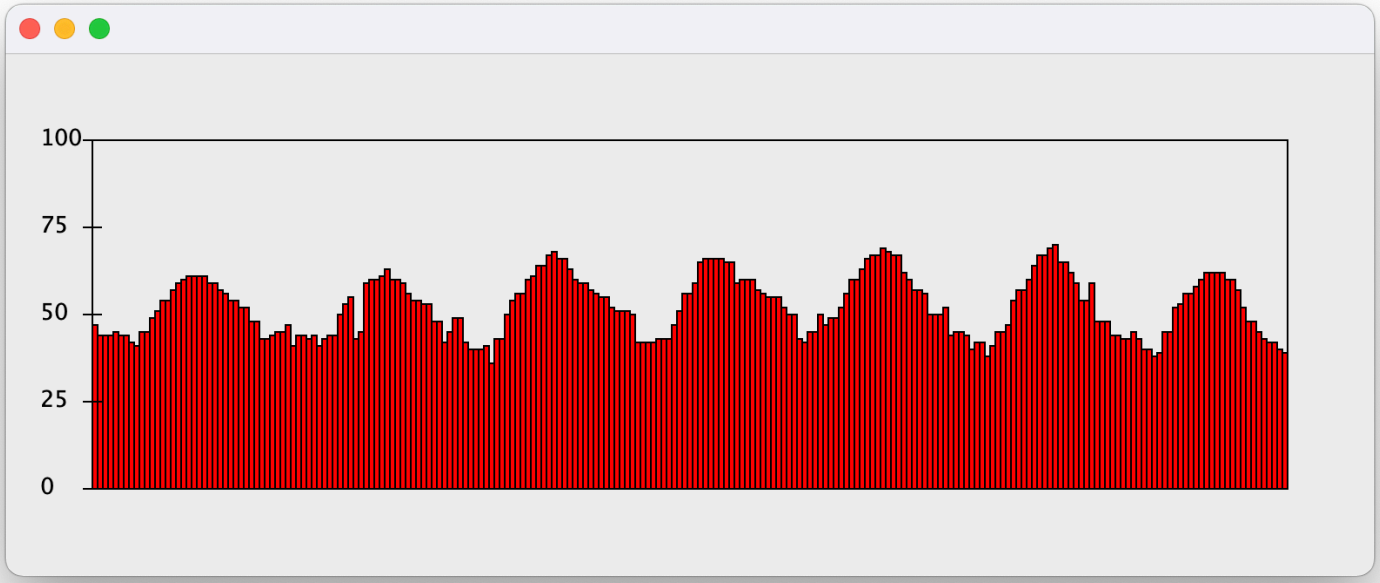


ONE MORE LITTLE CHANGE

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }
}
```

add top number label

ADD TOP Y-AXIS LABEL



questions?

NOTE: INTS WILL CAUSE PROBLEMS
THIS CODE ONLY WORKS IF
graphHeight % maxY = 0
graphHeight / maxY is an integer

CODE FOR ARBITRARY SCALING

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    double maxY = 120; //maximum y value we will plot
    double scale = ((double)graphHeight)/maxY;    //scale factor
    System.out.println(scale);
    for (int i=0; i<rows; i++) {
        int temperature = (int)(data[i][0]*scale);
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    int ticSpacing = 20;
    int numTicks = (int)(maxY/ticSpacing);
    int pixelsPerTick = graphHeight/numTicks;
    System.out.println(numTicks);
    for (int i=0;i<=numTicks;i++) {
        g.drawLine(spacer-5,i*pixelsPerTick+spacer,spacer+5,i*pixelsPerTick+spacer);
        g.drawString(String.valueOf(i*ticSpacing),spacer-30, height-(i*pixelsPerTick+spacer)+3);
    }
}
```

use double type variables
+ change rest of code to
accommodate doubles

KEEP SIMPLER CODE, BUT BE AWARE OF LIMITATIONS

questions?

WHERE WE ARE

- ~~Add color~~
- ~~Add space for axes around graph~~
- ~~Draw square around graph area~~
- ~~Draw y axis tic marks to show scale and values~~
- Draw x axis tic marks to show scale and values
- Draw axis labels
- Draw title

DRAW X-AXIS TIC MARKS

WHAT IS X-AXIS?
TIME: HOURLY READINGS

LET'S DRAW A TIC MARK EVERY 24 HOURS/EVERY DAY

DRAW X-AXIS TIC MARKS

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=1;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }

    //draw x tic marks
    int oneDay = 24;
    for (int i=0;i<=rows;i=i+oneDay) {

    }
}
```

tic mark every 24 hours

loop through all rows in data array

DRAW X-AXIS TIC MARKS

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=1;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }

    //draw x tic marks
    int oneDay = 24;
    for (int i=0;i<=rows;i=i+oneDay) {
        g.drawLine(i*rectangleWidth+spacer,height-spacer+5,i*rectangleWidth+spacer,height-spacer-5);
    }
}
```

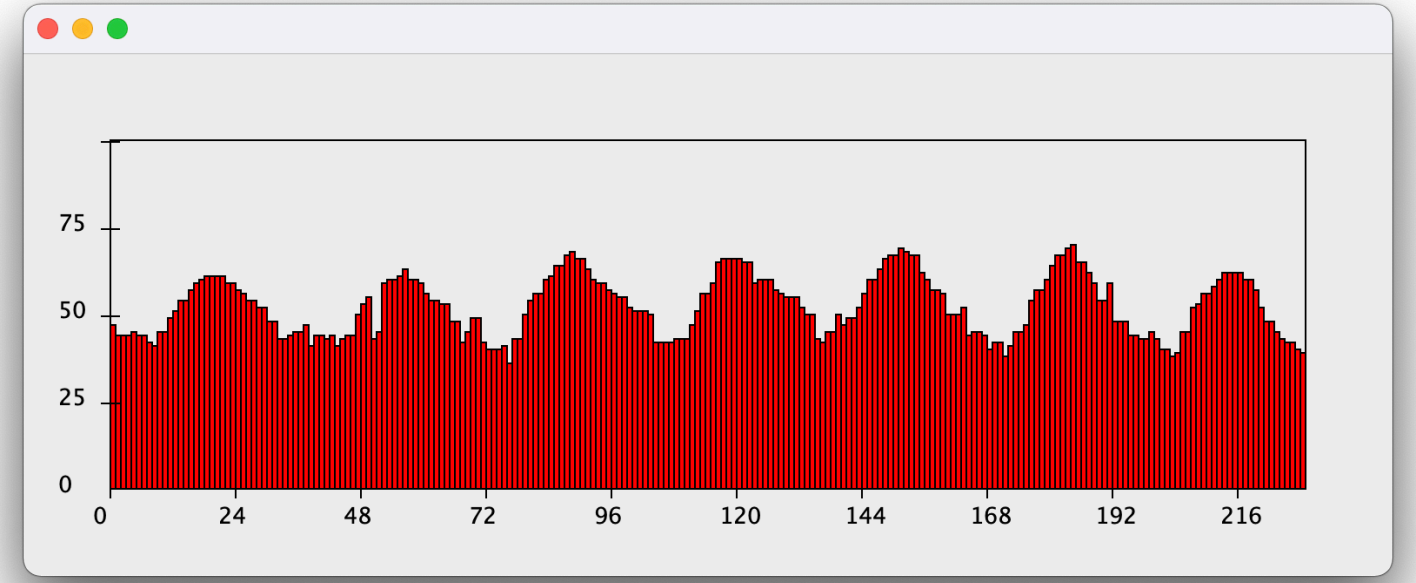
draw tic mark

DRAW X-AXIS TIC MARKS

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=1;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }

    //draw x tic marks
    int oneDay = 24;
    for (int i=0;i<=rows;i=i+oneDay) {
        g.drawLine(i*rectangleWidth+spacer,height-spacer+5,i*rectangleWidth+spacer,height-spacer-5);
        g.drawString(String.valueOf(i),i*rectangleWidth+spacer-10, height-spacer+20);
    }
}
```

draw text

ADD X-AXIS TIC MARKS



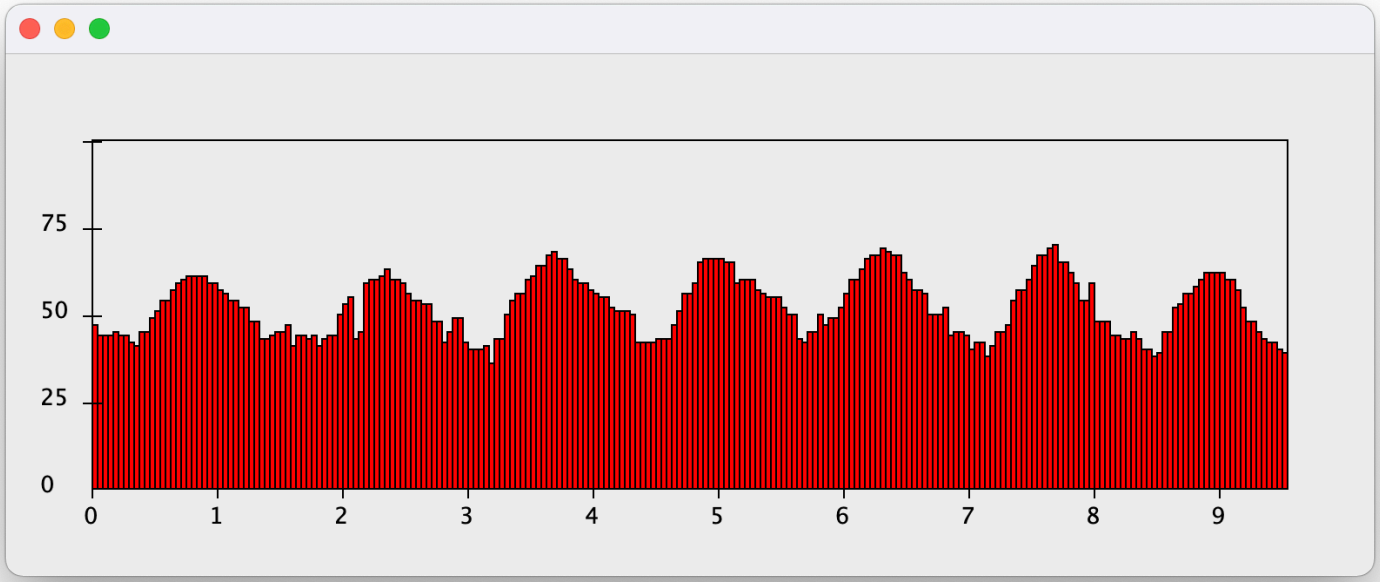
SEE ANY PROBLEMS?

CHANGE UNITS TO DAYS

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=1;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }

    //draw x tic marks
    int oneDay = 24;
    for (int i=0;i<=rows;i=i+oneDay) {
        g.drawLine(i*rectangleWidth+spacer,height-spacer+5,i*rectangleWidth+spacer,height-spacer-5);
        g.drawString(String.valueOf(i/oneDay),i*rectangleWidth+spacer-5, height-spacer+20);
    }
}
```

change units

SEE ANY PROBLEMS?



MORE DATA POINTS THAN THERE SHOULD BE!
SHOULD BE ONLY 7 DAYS

LOOK AT THE DATA

Hourly temperature (°F) and humidity (%) readings for a week in November

date	temperature	humidity
2021-11-11T00:52:00	47	34
2021-11-11T01:52:00	44	35
2021-11-11T02:00:00	44	35
2021-11-11T02:52:00	44	34
2021-11-11T03:52:00	45	35
2021-11-11T04:52:00	44	37
2021-11-11T05:00:00	44	37
2021-11-11T05:52:00	42	40
2021-11-11T06:52:00	41	41
2021-11-11T07:52:00	45	37
2021-11-11T08:00:00	45	37
2021-11-11T08:52:00	49	33
2021-11-11T09:52:00	51	31
2021-11-11T10:52:00	54	28
2021-11-11T11:00:00	54	28
2021-11-11T11:52:00	57	24
2021-11-11T12:38:00	59	19

Hourly temperature (°F) and humidity (%) readings for a week in November

date	temperature	humidity
2021-11-11T00:52:00	47	34
2021-11-11T01:52:00	44	35
2021-11-11T02:00:00	44	35
2021-11-11T02:52:00	44	34
2021-11-11T03:52:00	45	35
2021-11-11T04:52:00	44	37
2021-11-11T05:00:00	44	37
2021-11-11T05:52:00	42	40
2021-11-11T06:52:00	41	41
2021-11-11T07:52:00	45	37
2021-11-11T08:00:00	45	37
2021-11-11T08:52:00	49	33
2021-11-11T09:52:00	51	31
2021-11-11T10:52:00	54	28
2021-11-11T11:00:00	54	28
2021-11-11T11:52:00	57	24
2021-11-11T12:38:00	59	19

DATA CLEANING

- The process of preparing data by removing bad data
- Bad data may be incorrect, irrelevant, duplicate, badly formatted, etc.
- In our case: additional non-hourly readings mixed in with hourly readings
- Data cleaning is *always* a part of working with data
- Data, especially data you get from a 3rd party, will always have issues that need to be fixed
- A big part of data science is data cleaning

I CREATED A CLEAN DATA FILE DOWNLOAD IT HERE:

https://handandmachine.cs.unm.edu/classes/CS152_Fall2021/sampleCode/abq_weather_cleaned.csv

MOVE TO YOUR PROJECT FOLDER

LOOK AT THE DATA

Hourly temperature (°F) and humidity (%) readings for a week in November

date	temperature	humidity
2021-11-11T00:52:00	47	34
2021-11-11T01:52:00	44	35
2021-11-11T02:52:00	44	34
2021-11-11T03:52:00	45	35
2021-11-11T04:52:00	44	37
2021-11-11T05:52:00	42	40
2021-11-11T06:52:00	41	41
2021-11-11T07:52:00	45	37
2021-11-11T08:52:00	49	33
2021-11-11T09:52:00	51	31
2021-11-11T10:52:00	54	28
2021-11-11T11:52:00	57	24
2021-11-11T12:52:00	60	18
2021-11-11T13:52:00	61	17
2021-11-11T14:52:00	61	18
2021-11-11T15:52:00	61	18
2021-11-11T16:52:00	59	20
2021-11-11T17:52:00	57	18

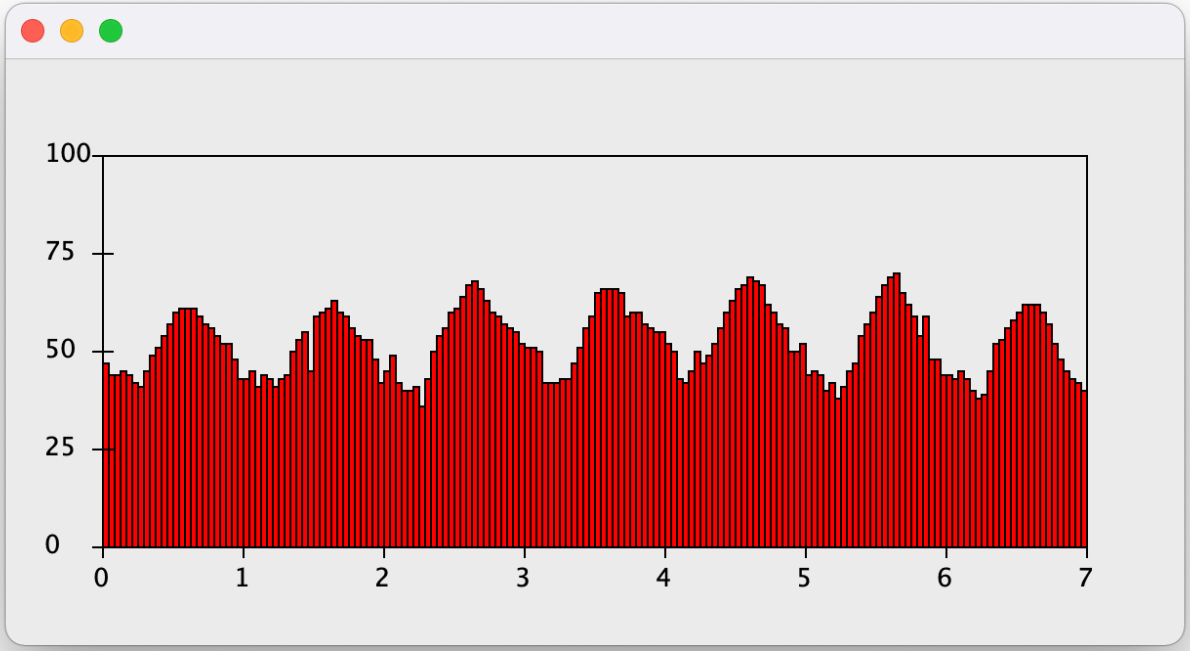
EDIT CODE TO USE CLEAN DATA

```
public class DataVisualizationTest extends BasicPanel {
    int[][] data;
    int rows;
    final String FILENAME = "abq_weather_cleaned.csv";
    final int rectangleWidth = 3;
    final int graphHeight = 200;
    final int spacer = 50;
```

notice how easy it is to use a different file for our program

just change one line of code

YAY, 7 DAYS!



WHERE WE ARE

- ~~Add color~~
- ~~Add space for axes around graph~~
- ~~Draw square around graph area~~
- ~~Draw y axis tic marks to show scale and values~~
- ~~Draw x axis tic marks to show scale and values~~
- Draw axis labels
- Draw title

DRAW X-AXIS LABEL

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }

    //draw x tic marks
    int oneDay = 24;
    for (int i=0;i<=rows;i=i+oneDay) {
        g.drawLine(i*rectangleWidth+spacer,height-spacer+5,i*rectangleWidth+spacer,height-spacer-5);
        g.drawString(String.valueOf(i/oneDay),i*rectangleWidth+spacer-5, height-spacer+20);
    }
    g.drawString("days", width/2-10, height-spacer+40);
}
```

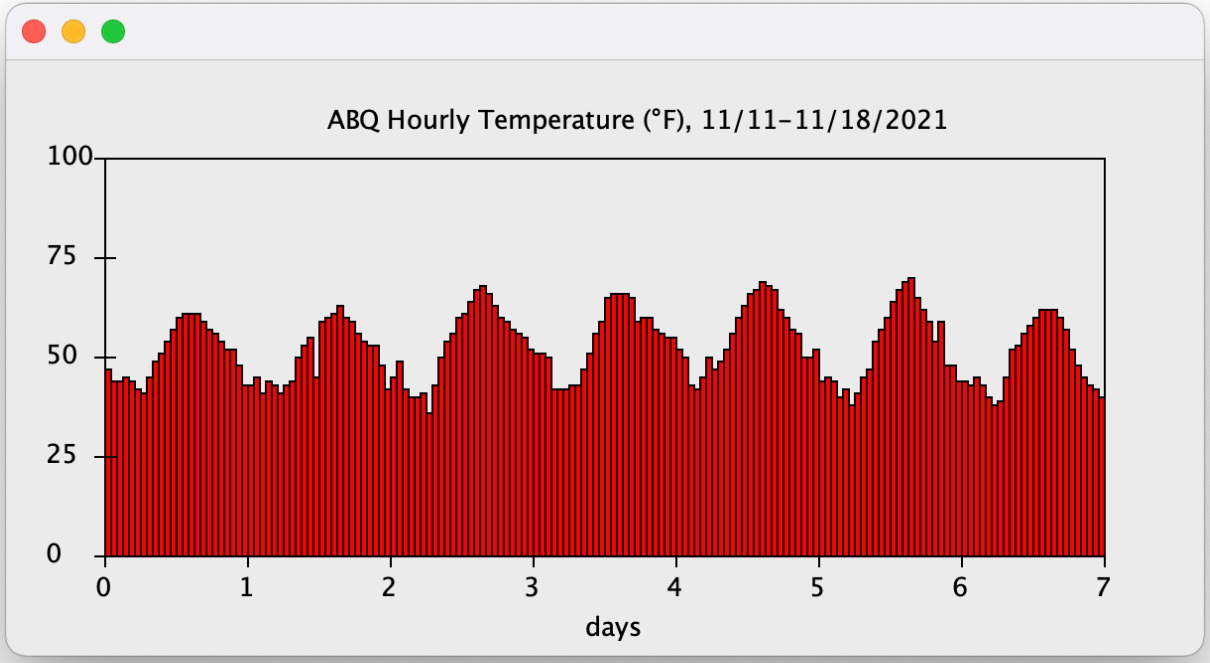
DRAW TITLE

```
void barGraph(Graphics g) {
    Color graphColor = Color.RED;
    int maxY = 100; //maximum y value we will plot
    int scale = graphHeight/maxY;   //scale factor
    for (int i=0; i<rows; i++) {
        int temperature = data[i][0]*scale;   //get temperature data for that row
        //draw the rectangle
        g.setColor(graphColor);
        g.fillRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
        //draw the rectangle outline
        g.setColor(Color.BLACK);
        g.drawRect(i*rectangleWidth+spacer, height-temperature-spacer, rectangleWidth, temperature);
    }
    g.drawRect(spacer,spacer,rectangleWidth*rows,graphHeight);

    //draw y tic marks
    for (int i=0;i<=graphHeight;i=i+25*scale) {
        g.drawLine(spacer-5,i+spacer,spacer+5,i+spacer);
        g.drawString(String.valueOf(i/scale),spacer-30, height-(i+spacer)+3);
    }

    //draw x tic marks
    int oneDay = 24;
    for (int i=0;i<=rows;i=i+oneDay) {
        g.drawLine(i*rectangleWidth+spacer,height-spacer+5,i*rectangleWidth+spacer,height-spacer-5);
        g.drawString(String.valueOf(i/oneDay),i*rectangleWidth+spacer-5, height-spacer+20);
    }
    g.drawString("days", width/2-10, height-spacer+40);

    //draw title
    g.drawString("ABQ Hourly Temperature (°F), 11/11-11/18/2021", width/2-140, spacer-15);
}
```

WHERE WE ARE

- ~~Add color~~
- ~~Add space for axes around graph~~
- ~~Draw square around graph area~~
- ~~Draw y axis tic marks to show scale and values~~
- ~~Draw x axis tic marks to show scale and values~~
- ~~Draw axis labels~~
- ~~Draw title~~

(FINALLY) A NICE BAR GRAPH!



questions?

SOME COMMENTS

- Would normally use libraries to do many of these things: parse data from a csv, draw tic marks and units, scale data, etc.
- It's useful to understand what those libraries (and software like Excel) are doing "under the hood"
- Java isn't a very good language for data visualization
- Python is great
- R is great

Thank you!

CS 152
Professor: Leah Buechley
TAs: Melody Horn, Noah Garcia, Andrew Geyko, Juan Ormaza
Time: MWF 10:00-10:50am
https://handandmachine.cs.unm.edu/classes/CS152_Fall2021/