Workshop #3

Regression & Prediction

Appalachian A. I. Corps @ UTK

Notes

Lesson Objective

In this lesson, you will learn how to use scatterplots and regression lines in Python to predict nitrate levels from RGB color values on test strips.

Materials Needed:

- A computer with a webcam
- A web browser (Chrome, Firefox, or Safari)

Notes

Workshop Structure

Navigate to:

https://tinyurl.com/aaic-wq-3

Notes

Review

Checkpoint 1. a: Review—Looking back to Workshop #2

Last workshop we learned:

- AI: Classification
  - Model Accuracy
- Agricultural Uses of Classification
- Data Ownership
- Computers & Color

Notes

Section 1

Quick Catch Up: Computers & Color Activity

Notes

RGB Values –> Color

Checkpoint 7. a: Using RGB Values to Create Color

Materials Needed:

- Slider Tool on Pg. 0
- Handout from last workshop

Notes

Using RGB Values to Create Color

- Use the slider tool below to convert the RGB values (from last workshop) to colors
- Record your answers on the handout
- We'll do one together!

Notes

Using RGB Values to Create Color

Checkpoint 7. b: Use the slider tool!
What color does this RGB value represent? (110, 164, 212)
Just like the computer last workshop, try to classify/make a prediction about what fruit this could be!

Notes

Section 2

Workshop #3

Notes

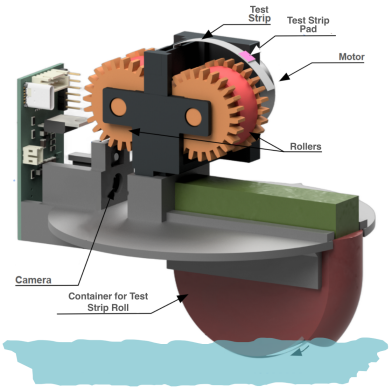
Remember Me, Smokey Buoy!?

We met Smokey Buoy last workshop and learned a bit about how it works.

Notes

Smokey Buoy: Components

Let's recall Smokey's components and how they work together

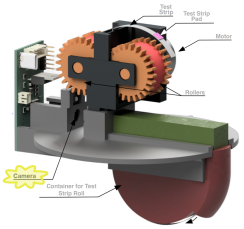


Notes

Smokey Buoy: Camera

Smokey Buoy's camera has two jobs:

- **Watch for a test pad**
  - We talked about this last workshop!
  - *Recall:* What is the process called?
- **When pad is present, take a picture**
  - We'll discuss what happens with the picture today!
  - *A new process!*



Notes

Section 3

Introduction to Regression

Notes

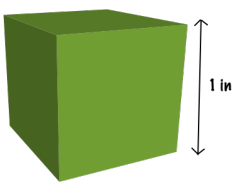
Introduction to Regression

- Last workshop, we learned about **classification**.
- In this workshop, we will learn about **regression**.
- Regression is all about **predicting** something (a number!) from something else (other numbers).

Notes

Scenario 1: Cube Towers

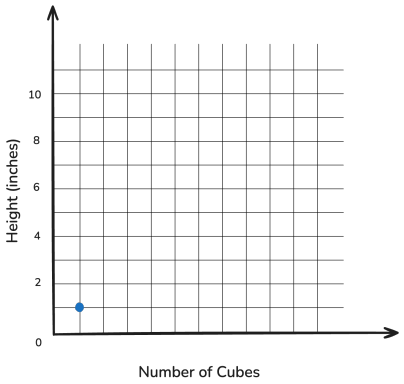
- We want to build a tower
- We have 1" inch cubes to use



Notes

Let's Predict! — 1 Cube

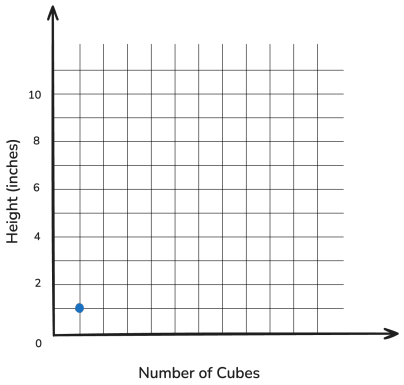
# of Cubes	Height (inches)
1	1



Notes

Let's Predict! — 2 Cubes

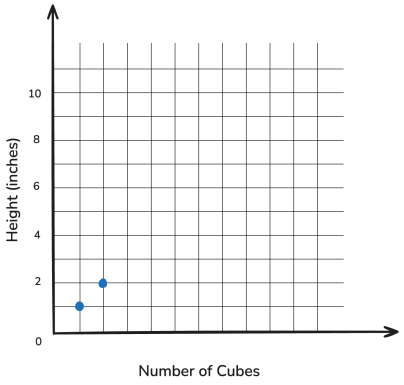
# of Cubes	Height (inches)
1	1
2	



Notes

Let's Predict! — 2 Cubes

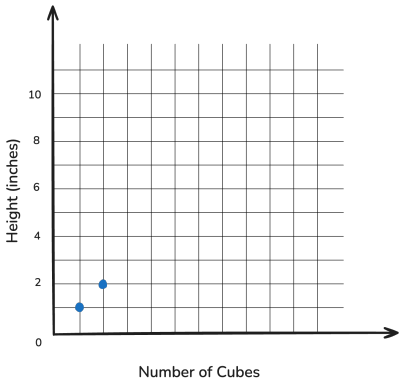
# of Cubes	Height (inches)
1	1
2	2



Notes

Let's Predict! — 3 Cubes

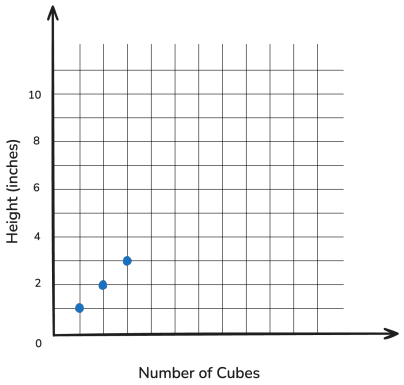
# of Cubes	Height (inches)
1	1
2	2
3	



Notes

Let's Predict! — 3 Cubes

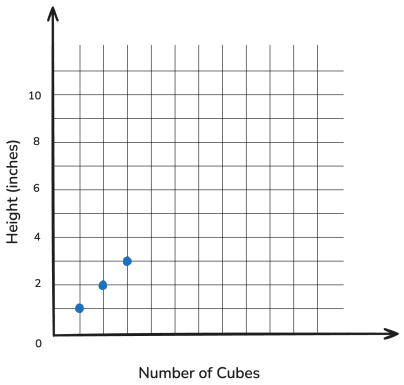
# of Cubes	Height (inches)
1	1
2	2
3	3



Notes

Let's Predict! — 4 Cubes

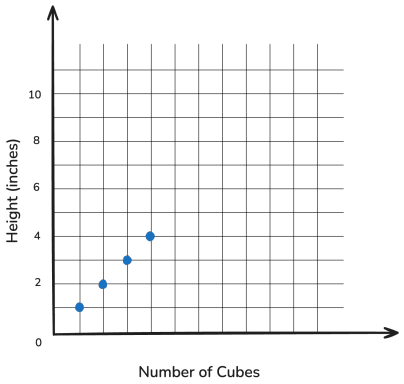
# of Cubes	Height (inches)
1	1
2	2
3	3
4	



Notes

Let's Predict! — 4 Cubes

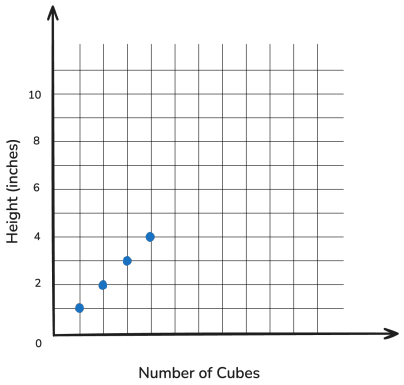
# of Cubes	Height (inches)
1	1
2	2
3	3
4	4



Notes

Let's Predict! — 5 Cubes

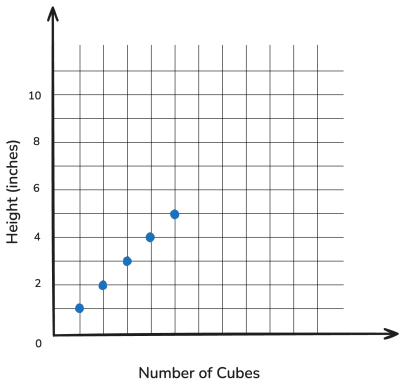
# of Cubes	Height (inches)
1	1
2	2
3	3
4	4
5	



Notes

Let's Predict! — 5 Cubes

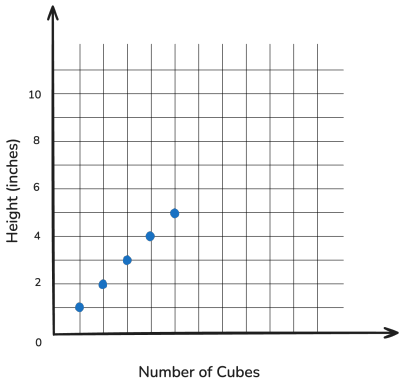
# of Cubes	Height (inches)
1	1
2	2
3	3
4	4
5	5



Notes

Let's Predict! — 10 Cubes

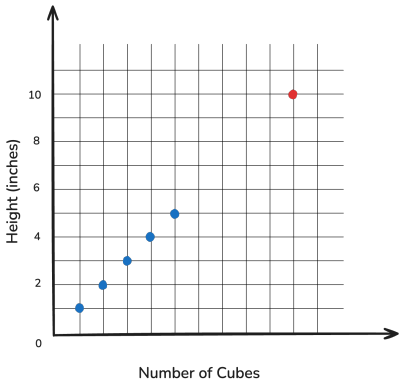
# of Cubes	Height (inches)
1	1
2	2
3	3
4	4
5	5
10	



Notes

Let's Predict! — 10 Cubes

# of Cubes	Height (inches)
1	1
2	2
3	3
4	4
5	5
10	10



Notes

Discuss: In Your Group

Checkpoint 2. a: Q1: How tall will our tower be if we use **100 cubes**? **Q2:** Your friend argues that the tower will be 99 inches tall. What would you tell him? Why?

Notes

Scenario 2: Cheap Uncle Bob

- We want to build a much taller tower than our current 10" one, but we ran out of 1" cubes.
- Uncle Bob volunteers to make us more cubes — cheaper!

Notes

Scenario 2: Cheap Uncle Bob

Oh no! Uncle Bob's cubes are all slightly different heights!

Notes

Discuss: In Your Group

Checkpoint 2. b: How will Uncle Bob's new cubes affect our tower height predictions?

Notes

Section 4

The Case for Regression

Notes

The Case for Regression

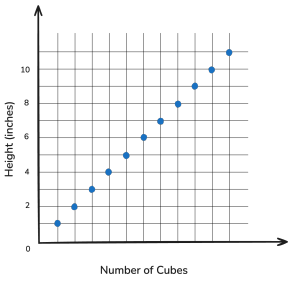


Figure 1: True with perfectly 1" cubes

Notes

The Case for Regression

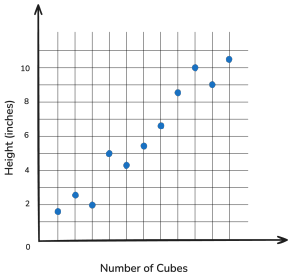


Figure 2: Reality with Uncle Bob's cubes

Bob's cubes saved us money, but now tower heights are all over the place. We need a better way to predict.

Notes

How Do We Fit Our Line?

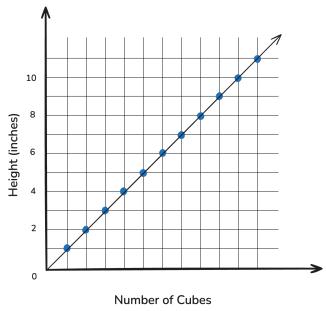


Figure 3: Very clear line with perfect cubes

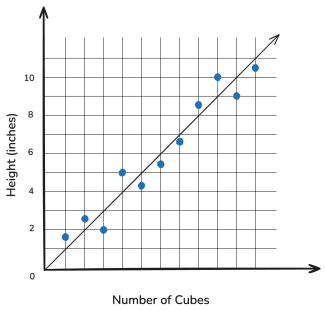


Figure 4: Need **regression** — the mathematical best-fit line

Notes

Smokey Buoy: Regression

- The buoy also uses **regression** to predict nitrate levels.
- Let's learn a bit more about this!

Notes

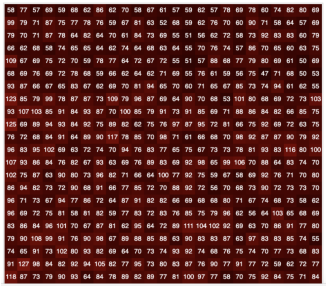
Section 5

Regression Activity — Pt. I:RGB and Scatterplots

Notes

Averaging RGB

In Workshop #2, we learned how computers "see" color through RGB values. The buoy takes **all the pixels** for each test pad and finds their **mean**.



Notes

Averaging RGB

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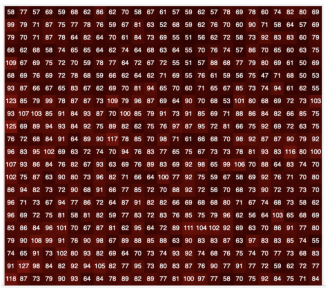
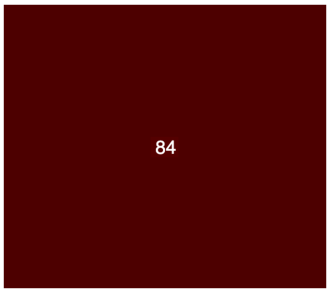
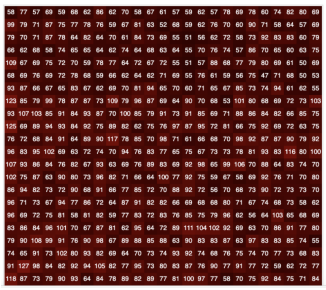




Notes

Averaging RGB

In our applet (for the next activity), we split the pixels into a grid and meaned each section. We will treat the center box like the test pad (use that number).



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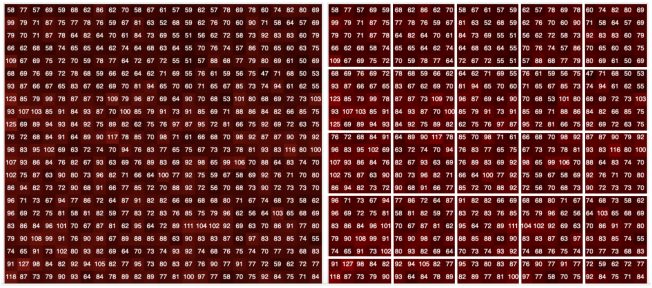

Notes

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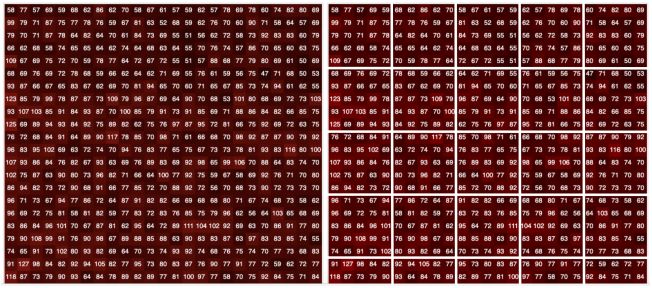
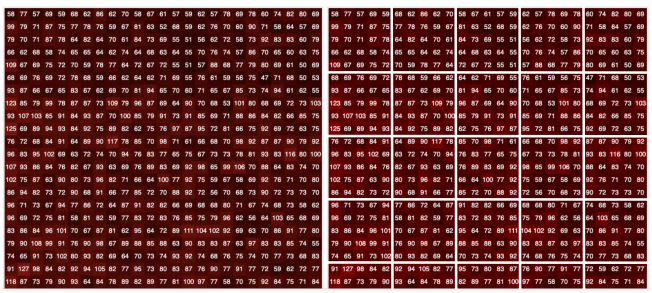


Notes

88	89	92	92	93
87	84	87	90	93
89	81	84	85	88
77	80	81	90	85
71	77	77	81	88

Averaging RGB

In our applet (for the next activity), we split the pixels into a grid and meaned each section. We will treat the center box like the test pad (use that number).



Notes

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87	84	87	90	93
89	81	84	85	88
77	80	81	90	85
71	77	77	81	88

88	89	92	92	93
87	84	87	90	93
89	81	84	85	88
77	80	81	90	85
71	77	77	81	88

Section 6

Groupwork!

Notes

RGB Activity (Pt. I)

Materials Needed:

- RGB Applet V2
- Deck of Purple "Nitrate Test Pad" Cards
- Pencil / Highlighter (optional)
- Handout / Dot Stickers
- Large Graph Paper / Poster Markers

Notes

RGB Activity (Pt. I)

Checkpoint 4. a: Read water quality test data like a computer!

Roles

- *Human Buoy* (1 person): Needs the nitrate test cards and computer handy
- *Data Recorders* (2+ people): Need handout and pencil

Notes

RGB Activity (Pt. I) — Instructions

1. **HB:** Open the RGB Applet V2 in a new tab.
2. **HB:** Take a deck from your water testing deck and hold it in front of your webcam.
3. **DRs:** Using the middle square in the frame, record the RGB values on your handout.
4. Repeat for all other cards in deck.

Notes

RGB Activity (Pt. I) — Instructions

5. When finished, make sure all group members have the data values recorded on their handouts.

Notes

Section 7

Activity Pt. II Scatterplots!

Notes

Activity (Pt. II) - Scatterplots

Notes

Activity (Pt. II) — Instructions

For this portion, each group is assigned either **red**, **green**, or **blue**, based on the color of your stickers!

Notes

Activity (Pt. II) — Instructions

Checkpoint 4. b: Plotting R, G or B values against nitrate concentrations.

1. Using the round stickies and graph paper, create a scatterplot.
2. Color values (R, G, or B — per your group) go on the **x-axis**.
3. Nitrate concentrations go on the **y-axis**.

Notes

Section 8

Activity — Pt. III:Regression Modeling

Notes

Regression Modeling

Notes

Storing Your Data

Checkpoint 5. a: Storing your team's data in lists!

Replace the ?? placeholders with your color values and nitrate concentrations.

IMPORTANT: Values must be in the **exact same order**.

Click **Run Code** to store your data.

```
color_data = [??, ??, ??, ??, ??, ??, ??, ??]
nitrate_ppm = [??, ??, ??, ??, ??, ??, ??, ??]

print(color_data)
print(nitrate_ppm)

color_data, nitrate_ppm = process_data(color_data, nitrate_ppm)
df = process_df(color_data, nitrate_ppm)
```

Notes

Storing Your Data

Replace the ?? placeholders with your color values and nitrate concentrations.

IMPORTANT: Values must be in the **exact same order**.

Click **Run Code** to store your data.

```
color_data = [188, 179, 176, 176, 172, 167, 166, 162]
nitrate_ppm = [0, 1, 2, 3, 4, 5, 6, 7]

print(color_data)
print(nitrate_ppm)

color_data, nitrate_ppm = process_data(color_data, nitrate_ppm)
df = process_df(color_data, nitrate_ppm)
```

```
[188, 179, 176, 176, 172, 167, 166, 162]
[0, 1, 2, 3, 4, 5, 6, 7]
```

Notes

Recreating Your Team's Scatterplot

Checkpoint 5. b: Scatterplots in Python!

Notes

Recreating Your Team's Scatterplot

Replace the ?? placeholders:

- First blank → x variable: `color_data`
- Second blank → y variable: `nitrate_ppm`

Click **Run Code** to create a scatterplot matching your group's paper plot.

```
plt.figure(figsize=(6, 5))
plt.scatter(df["??"], df["??"], s=60, color="black")
plt.title("Nitrate vs. Color")
plt.xlabel("Color")
plt.ylabel("Nitrate (ppm)")
plt.tight_layout()
plt.show()
```

Notes

Recreating Your Team's Scatterplot

Replace the ?? placeholders:

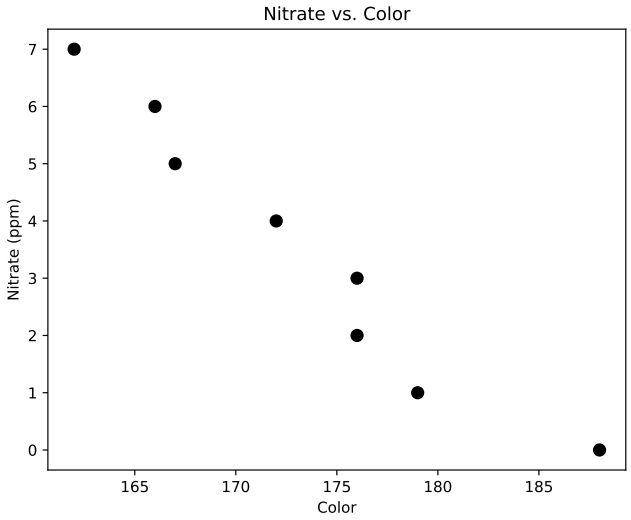
- First blank → x variable: `color_data`
- Second blank → y variable: `nitrate_ppm`

Click **Run Code** to create a scatterplot matching your group's paper plot.

```
plt.figure(figsize=(6, 5))
plt.scatter(df["color_data"], df["nitrate_ppm"], s=60, color="black")
plt.title("Nitrate vs. Color")
plt.xlabel("Color")
plt.ylabel("Nitrate (ppm)")
plt.tight_layout()
plt.show()
```

Notes

Recreating Your Team's Scatterplot



Notes

Discussion: Placing the Line of Best Fit

Materials Needed: Complete Scatterplot, Yardstick

With your group, discuss where your regression line will likely fall on your scatterplot. Once your group has made a decision, place your yardstick on top of your scatterplot as if it's the line.

Note: Lines will likely vary across groups, given that you are working with different color channels!

Notes

Running the Linear Regression

Checkpoint 5. c: Running a regression in Python!

Replace the ?? placeholders:

- First blank → x variable: `color_data`
- Second blank → y variable: `nitrate_ppm`

Click **Run Code** to generate the line of best fit equation.

```
slope, intercept = linear_regression(??, ??)

print("slope (m):", slope)
print("intercept (b):", intercept)
```

Notes

Running the Linear Regression

Replace the ?? placeholders:

- First blank → x variable: `color_data`
- Second blank → y variable: `nitrate_ppm`

Click **Run Code** to generate the line of best fit equation.

```
slope, intercept = linear_regression(color_data, nitrate_ppm)

print("slope (m):", slope)
print("intercept (b):", intercept)
```

```
slope (m): -0.2863027806385159
intercept (b): 53.101956745622886
```

Notes

From Regression to Equation

Checkpoint 5. d: Printing the Regression Equation

The linear regression produces the equation for the **line of best fit**.

Remember $y = mx + b$? We can just substitute!

Click **Run Code** to see the slope-intercept equation.

```
print(f"y = {slope:.2f}x + {intercept:.2f}")
```

Notes

From Regression to Equation

The linear regression produces the equation for the **line of best fit**.

Remember $y = mx + b$? We can just substitute!

Click **Run Code** to see the slope-intercept equation.

```
print(f"y = {slope:.2f}x + {intercept:.2f}")
```

```
y = -0.29x + 53.10
```

Notes

Plotting the Regression Line

Checkpoint 5. e: Plotting regression line in Python

Notes

Plotting the Regression Line

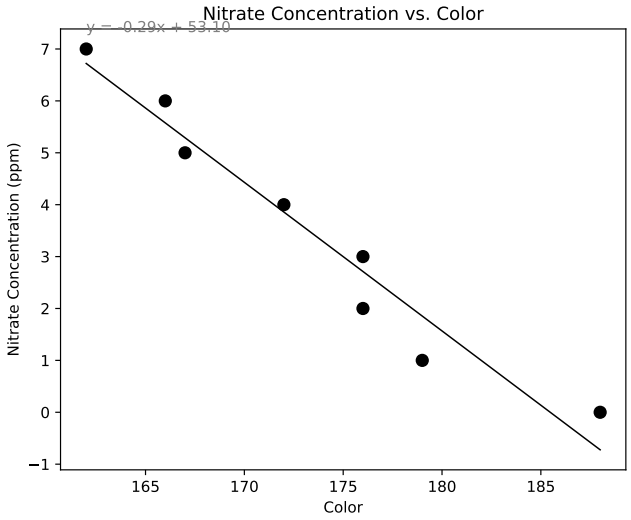
Click **Run Code** to plot the scatterplot with the regression line.

```
nitrate_pred = slope * color_data + intercept

plt.figure(figsize=(6, 5))
plt.scatter(color_data, nitrate_ppm, s=60, color="black")
plt.plot(color_data, nitrate_pred, color="black", linewidth=1)
plt.title("Nitrate Concentration vs. Color")
plt.xlabel("Color")
plt.ylabel("Nitrate Concentration (ppm)")
plt.text(
    min(color_data), max(nitrate_ppm),
    f"y = {slope:.2f}x + {intercept:.2f}\n",
    ha="left", fontsize=10, color="gray"
)
plt.tight_layout()
plt.show()
```

Notes

Plotting the Regression Line



Notes

Activity Pt. IV — Draw Line of Best Fit

Checkpoint 5. f: Plotting regression line on paper

Materials Needed:

- Poster Markers
- Completed Scatterplot
- Yardstick

Notes

Activity Pt. IV — Draw Line of Best Fit

Using the exact positioning Python generated, **copy the regression line onto your group's scatterplot**. When finished, bring your group's plot to the front of the class.

Notes

Section 9

Prediction & R^2

Notes

Making Predictions — Reload Your Data

Checkpoint 6. a: Storing your team's data in lists (again)!

Re-enter your color values and nitrate concentrations.

NOTE: You can copy/paste the two lists from the previous activity.

Click **Run Code** to re-load your data.

```
color_data = [188, 179, 176, 176, 172, 167, 166, 162]
nitrate_ppm = [0, 1, 2, 3, 4, 5, 6, 7]

# Do not change the code below ------------------------------------
color_data, nitrate_ppm = process_data(color_data, nitrate_ppm)
slope, intercept = linear_regression(color_data, nitrate_ppm)
print(f"Slope: {slope:.2f}, Intercept: {intercept:.2f}")
```

```
Slope: -0.29, Intercept: 53.10
```

Notes

Using the Model to Predict

Checkpoint 6. b: Predicting nitrate concentrations from your regression model (like the buoy)!

Notes

Using the Model to Predict

Now that we have our regression model, we can **predict** nitrate concentrations for new color values — even ones we didn't measure!

Click **Run Code**, then type any color value into the box to see the predicted nitrate concentration.

```
show_prediction_plot(color_data, nitrate_ppm, slope, intercept)
```

Notes

Using the Model to Predict

```
<IPython.core.display.HTML object>
```

Notes

Activity Pt. V: Predict New Concentrations

Materials Needed: - RGB Applet V2 - Three Additional "Nitrate Test Pad" Cards from Real Buoy Data (with RGB values printed) - Handout / Pencil

Notes

Activity Pt. V: Predict New Concentrations

1. Identify R, G, or B value for the new cards (per your group color).
2. Use the graphing tool to **predict the nitrate concentration (ppm)**.
3. Record these predictions on your handout.

Notes

Share Out: What Are Your Model Predictions?

Sample #	Red Model	Green Model	Blue Model
Sample 1			
Sample 2			
Sample 3			

Compare with the other groups — what do you notice? **How might we improve our model and, therefore, our predictions?** :::

Notes

Discuss: In Your Group

Materials Needed: Handout, Pencil

Checkpoint 6. e: Stop and Jot: An agriculture scenario **Scenario:** A local strawberry farm sells berries at small stands around town. They want to sell out every day! Some days are slower than others, so they're thinking about offering discounts to sell more. What makes a day slow or busy? What clues could help them predict when to offer a discount?

Notes

Section 10

Exit Ticket

Notes

Exit Ticket

Notes

Great job! You've learned so much!

Share what you've learned on the **Exit Ticket**.

Section 11

Exercises

Notes

Exercises

Want to practice what we've learned?

Try the **Exercises**.

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