

# Data Science in Intro Physics & Physical Science: Ideas from the STEMcoding Project

sketch.js

```
20 Temperature
21 i = 1;
22 for(t = 0; t < Year; t += 1) {
23   // Normal climate
24   // Average temperature
25   Temperature = 2*PI/Year*t + Tave +
  random(1);
26   Ndays_freezing_normal += 1;
27   // Global warming
28   // Temperature increase
29   Temperature[i] + Twarming;
30   Ndays_freezing_gw += 1;
31 }
32 };
```

Preview

Simulated Data for 40 lat. N. America Twarming (F) = 1.01  
Twarming (F) currently = 1.4  
# freezing days lost = 11

Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May June Jul

32 F

Days(<32F) = 48

Days(<32F) = 59

Global warming  
Normal climate

# Twarming

Prof. Chris Orban



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STEM coding

# A little about me

- Computational physics
- Plasma physics
- Education research
- Ph.D. in Physics from OSU



# STEMcoding Team



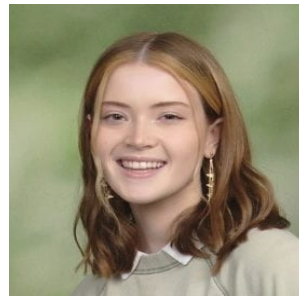
Prof. Chris Orban  
OSU physics



Kelsey Badger  
OSU data librarian



Prof. Scott Zimmerman  
OSU math



Jessica Kulp  
Now OSU education  
(OSU physics BS grad)



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# STEMcoding Team



Prof. Chris Orban  
OSU physics

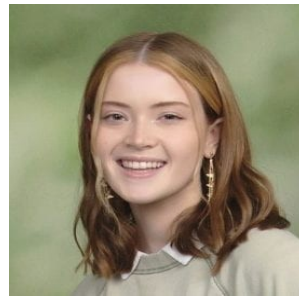


Kelsey Badger  
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You?



Jessica Kulp  
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Prof. Chris Orban  
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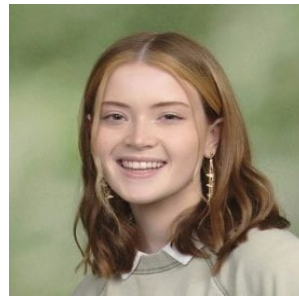


Kelsey Badger  
OSU data librarian



Prof. Scott Zimmerman  
OSU math

You?



Jessica Kulp  
Now OSU education  
(OSU physics BS grad)

Your  
student?



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# Outline

- A Brief History of the last decade of CS education
  - Including K12 perspective
- The STEMcoding Project
- Ideas!



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STEMcoding

## The Problem:

Students aren't adequately prepared to work with technology

## The Debate:

What does it mean to be "prepared to work with technology"?

What should the solution look like?

# Think back to 2013

- In 2013, only about 10% of high schools offered a CS class
- About ~4% of high school students taking CS before graduating high school
- Silicon valley people are self-taught
- Few browser based coding tools

Obama's 2<sup>nd</sup> Inauguration (2013)





2013: "What most schools don't teach"  
(answer: computer science)



# 2013: Non-profit formed to expand computer science

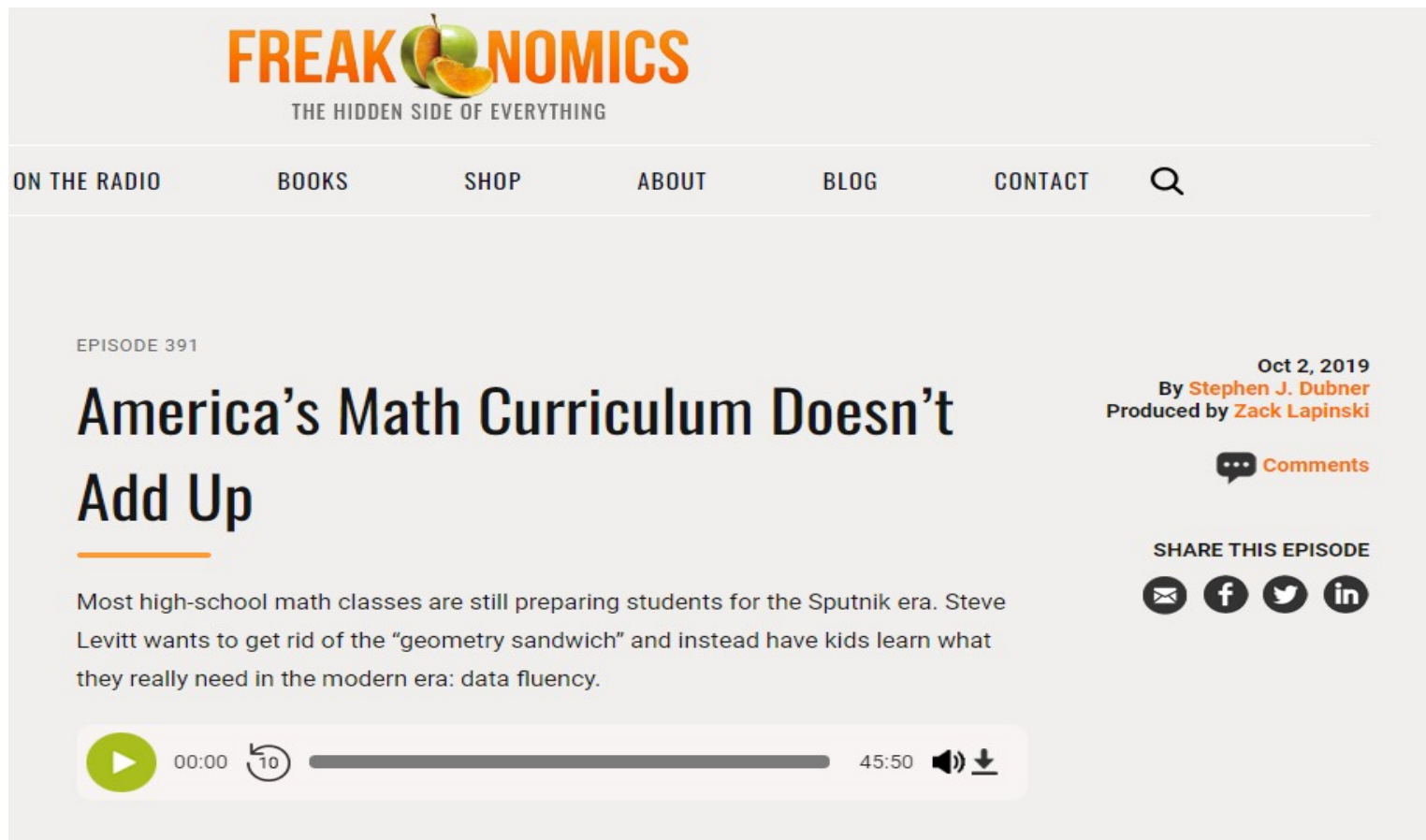


Code.org co-founder Hadi Petrovi and others celebrate the launch of their non-profit in 2013

# 2014: President Obama codes!



# 2019: Data Science in the spotlight



**FREAKONOMICS**  
THE HIDDEN SIDE OF EVERYTHING


ON THE RADIO   BOOKS   SHOP   ABOUT   BLOG   CONTACT   🔍

EPISODE 391





## America's Math Curriculum Doesn't Add Up





Most high-school math classes are still preparing students for the Sputnik era. Steve Levitt wants to get rid of the "geometry sandwich" and instead have kids learn what they really need in the modern era: data fluency.

Oct 2, 2019  
By **Stephen J. Dubner**  
Produced by **Zack Lapinski**

 **Comments**

SHARE THIS EPISODE

00:00   45:50  

# Freakonomics Episode in Brief

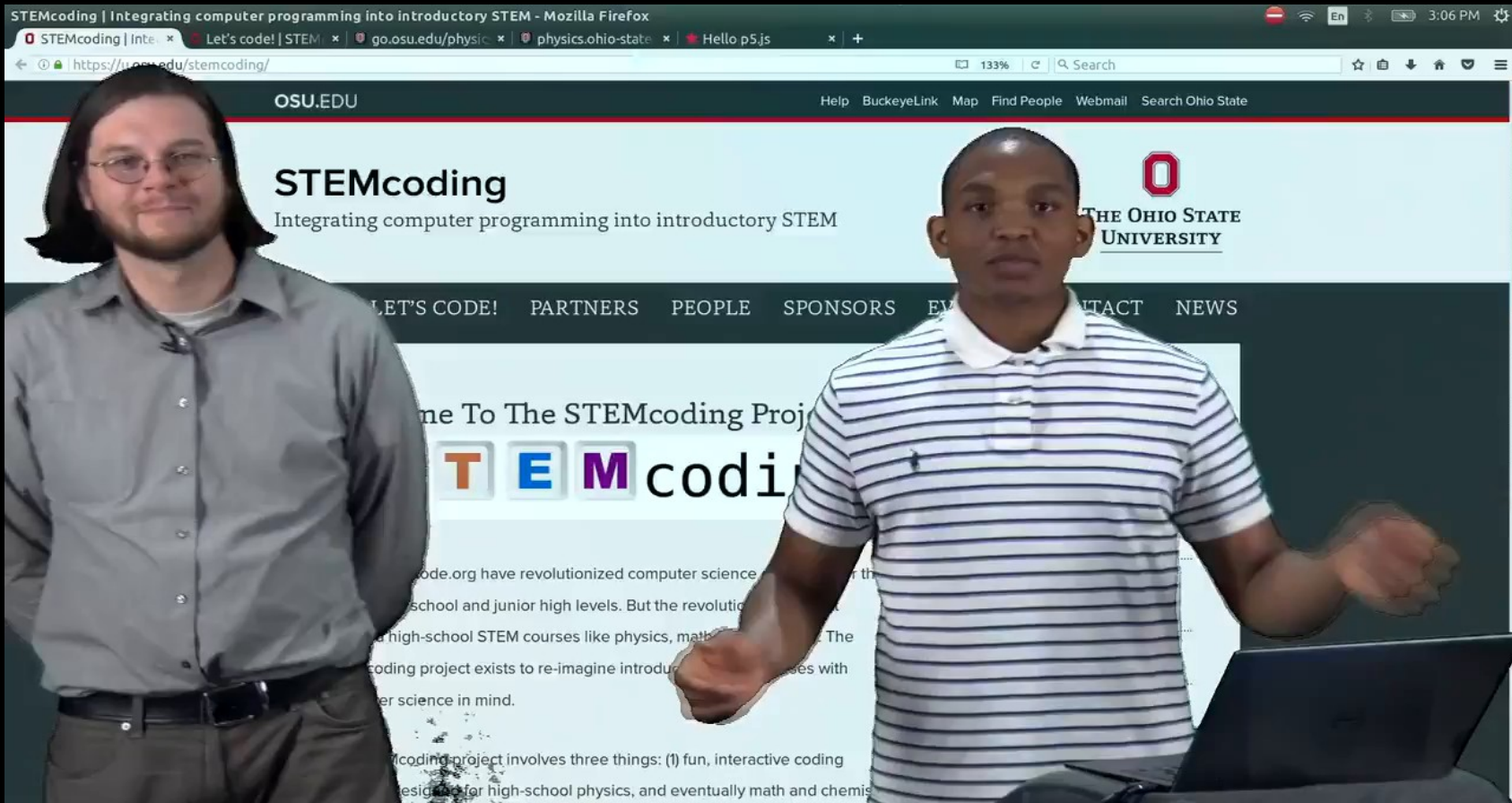
- Economist Steve Levitt expresses his frustration with his daughter's algebra homework
- But he does **NOT** join the chorus calling for more CS in schools
- Instead he calls for more “data science” in schools
- He highlights an initiative at UCLA to do just that

# What about higher ed?

- This is all mirrored in higher ed, including physics
- PICUP starts in 2016
- Recent push to include data skills in general education requirements




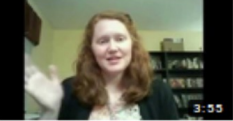




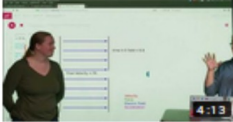
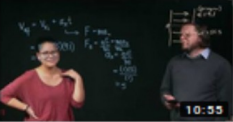








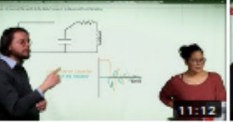



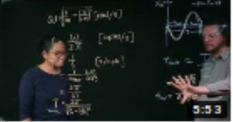
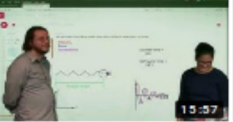


# STEMcoding Project



[youtube.com/STEMcoding](https://www.youtube.com/STEMcoding)



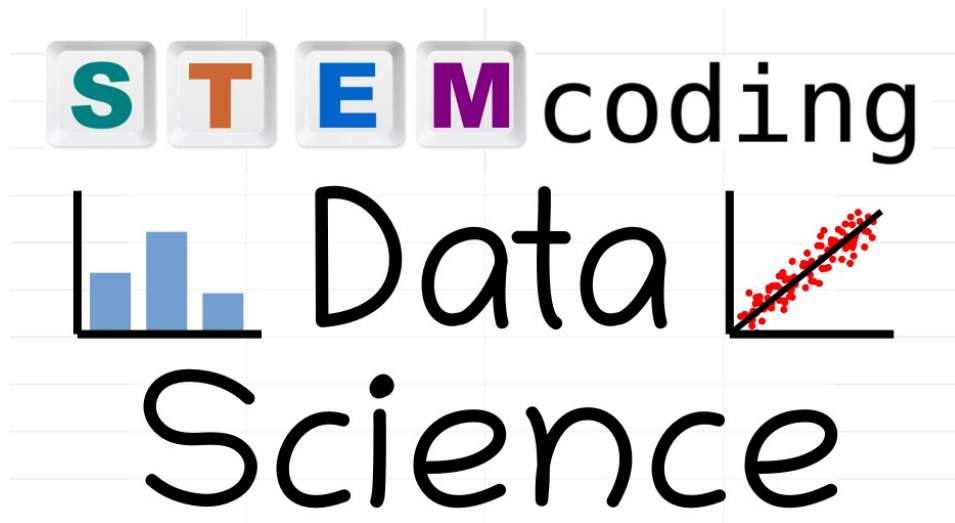
Uploads PLAY ALL ≡ SORT BY

 <b>STEM for All Video Showcase Submission! (2019)</b> 57 views • 1 week ago	 <b>Teachers! Come hang out with us for a week this summer at</b> 55 views • 3 weeks ago	 <b>3000 subscriber celebration!</b> 142 views • 1 month ago	 <b>How to use STEMcoding in an actual classroom (Part 3)</b> 166 views • 1 month ago	 <b>Help us raise funds for Central Ohio's biggest High school</b> 82 views • 2 months ago	 <b>Slingshot with Gravity! (Part 2)</b> 348 views • 4 months ago
 <b>Particle Accelerator! (Part 3)</b> 153 views • 4 months ago	 <b>Particle Accelerator! (Part 2)</b> 100 views • 4 months ago	 <b>Particle Accelerator! (Part 1)</b> 247 views • 4 months ago	 <b>Slingshot with Gravity! (challenge)</b> 721 views • 4 months ago	 <b>Slingshot with Gravity! (Part 5)</b> 123 views • 4 months ago	 <b>Slingshot with Gravity! (Part 4)</b> 100 views • 4 months ago
 <b>Slingshot with Gravity! (Part 3)</b> 138 views • 4 months ago	 <b>Slingshot with Gravity! (Part 1)</b> 364 views • 4 months ago	 <b>How to use STEMcoding in an actual classroom (Part 2)</b> 72 views • 4 months ago	 <b>RC circuit coding activity (Bonus Content!)</b> 72 views • 5 months ago	 <b>RCcircuit coding activity (Part 4) – RLC circuits!</b> 65 views • 5 months ago	 <b>RCcircuit coding activity (Part 3)</b> 53 views • 5 months ago
 <b>RC circuit coding activity (Part 2)</b> 49 views • 5 months ago	 <b>RCcircuit coding activity (Part 1)</b> 169 views • 5 months ago	 <b>Planetoids with a Spring (Part 5)</b> 57 views • 5 months ago	 <b>Planetoids with a Spring (Part 4)</b> 61 views • 5 months ago	 <b>Planetoids with a Spring (Part 3)</b> 36 views • 5 months ago	 <b>Planetoids with a Spring (part 2)</b> 41 views • 5 months ago

<https://www.youtube.com/STEMcoding>

# Hour of code activities

- 2017 release – Move the blob
- 2018 release
  - Asteroids & Lunar Lander
  - Pong & Bonk.io
  - Pi day
- 2019 release
  - Escape Velocity / Newtonian Black Holes
- 2021 release
  - Earth Day / Climate Change activity



+



Google Sheets

- The STEMcoding Project is designing a year long data science curriculum!
- Physical science & environmental science (& health) theme
- Emphasis on spreadsheet skills, including Excel (or Google Sheets)

# 2021 Hour of Code Activity: Earth Day

Introduction

Step 1. Get Climate Data

Step 2. Calculate Average Temperatures

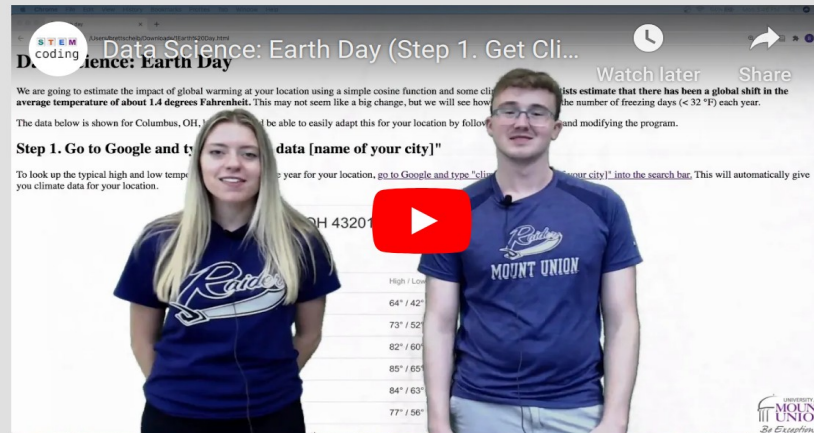
Step 3. Open the Code

Step 4. Add Your Temperatures

Step 5. Run the Code

Step 6. Temperature Variability

## Step 1. Go to Google and collect climate data



To look up the typical high and low temperatures throughout the year for your location, [go to Google and type "climate data \[name of your city\]" into the search bar](#). This will automatically give you climate data for your location.

The data below is shown for Columbus, OH, but you should be able to easily adapt this for your location by following the directions and modifying the program.



p5.js File Edit Sketch Help English Log In Sign up

Auto-refresh climate alpha 11 by ChrisOrban

```

20 Temper
21 i = 1;
22 for(t = 0; t < 365; t += 1) {
23
24 // Normal average temperature
25 Temp = (2*PI/Year*t) + Tave+
26 rand(1) * 10;
27 Ndays_freezing_normal += 1;
28 // Global warming
29 // Temperature increase
30 Temp = Temp + Twarming;
31 Ndays_freezing_gw += 1;
32 }

```

Preview

Simulated Data for 40 lat. N. America Twarming (F) = 1.01  
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Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May June Jul

32 F

#

Days(<32F) = 48  
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Global warming  
 Normal climate

Twarming

UNIVERSITY of MOUNT UNION  
 Be Exceptional

<http://go.osu.edu/earthdaycoding>

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 Data Science

# Air Pressure vs Height




Air Pressure! (designed by Prof. Chris Orban, Ohio State U.)

It turns out nearly all smartphones (iPhones and Android) and nearly all iPads have air pressure sensors (a.k.a. barometers). There are a couple of apps you can use to get a pressure reading. The one that seems to work best on all platforms is the [Arduino Science Journal](#).

**Step 0.** Download the [Arduino Science Journal](#) app.

*Note: It doesn't make a big difference if you use a smartphone. But if you do have an iPad, please go ahead and use it.*

**Step 1.** Open the app. Press "+" to open a new experiment. Tap the pencil icon in the lower right corner to edit the new experiment. Tap the "Variables" icon at the bottom of the screen to bring up the variable selection screen.

**Step 2.** Click on this symbol  (fourth symbol from the left). At this point your screen should look something like this:




**Arduino Science Journal**  
Think like a real scientist

OPEN

...d for this lab.



Symbol: 

At this

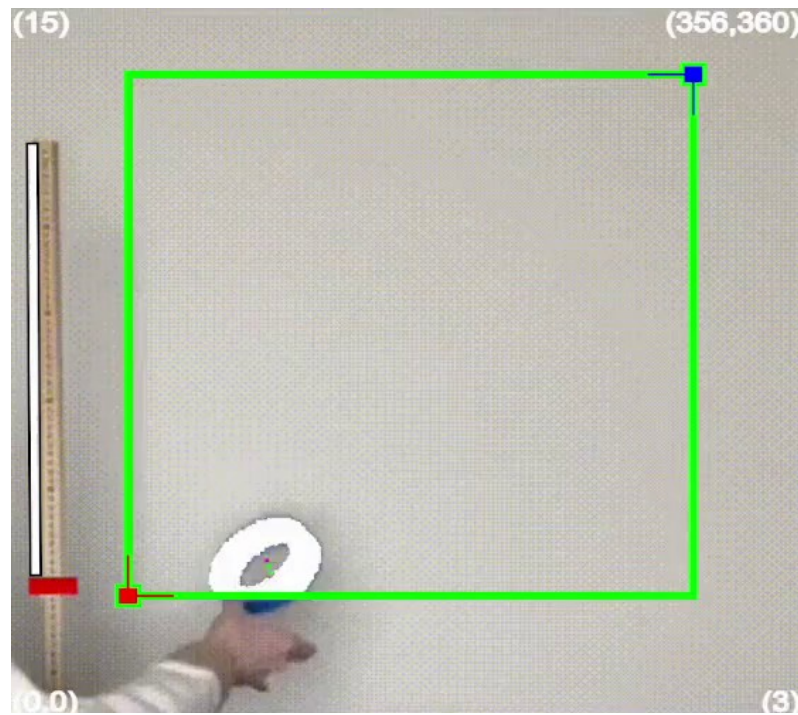
<https://go.osu.edu/pressure>



# STEMcoding Object Tracker

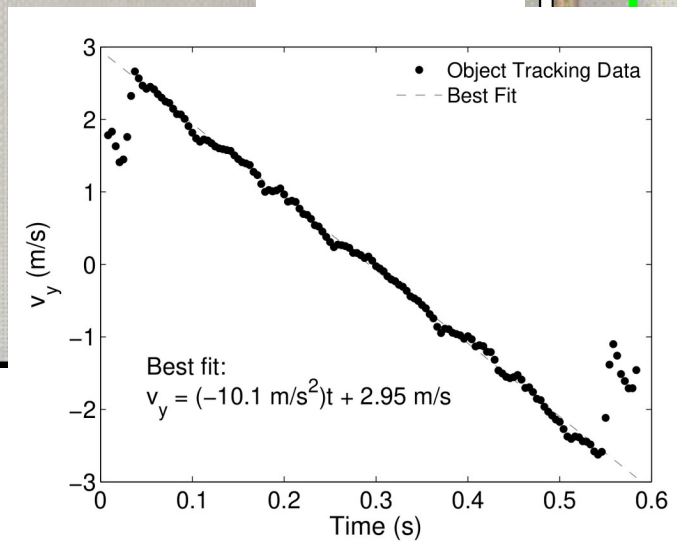
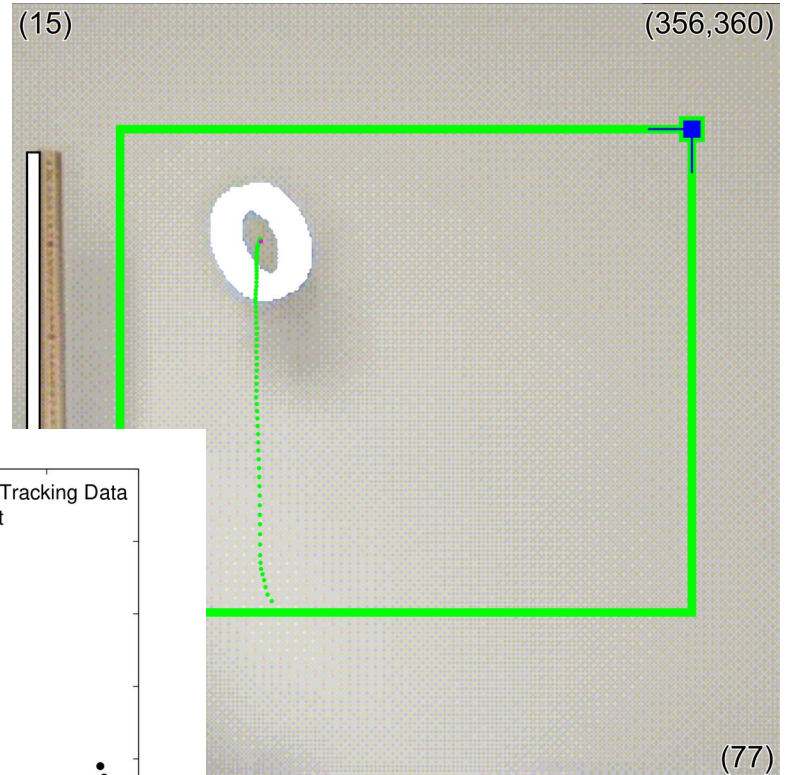
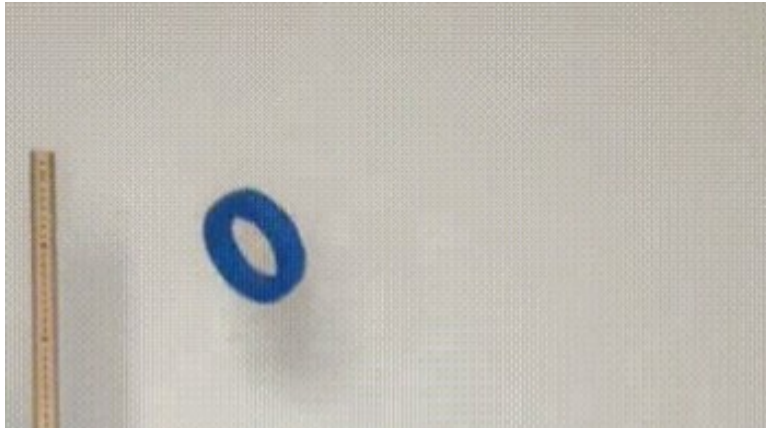


# Track colors not objects!



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# Track colors not objects!



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Data Science

## Methods to Simplify Object Tracking in Video Data

Orban, C. M.,<sup>1,2</sup> Zimmerman, S.,<sup>3,4,5</sup> Kulp, J.,<sup>1</sup> Boughton, J.,<sup>6</sup> Perrico, Z.,<sup>7</sup> Rapp, B.,<sup>7</sup> and Teeling-Smith, R.<sup>7</sup>

<sup>1</sup>Physics Department, The Ohio State University, 191 W Woodruff Ave, Columbus, OH 43210

<sup>2</sup>Physics Department, The Ohio State University at Marion, 1461 Mount Vernon Ave, Marion, OH 43302

<sup>3</sup>Department of Mathematics, The Ohio State University, 231 West 18th Avenue, Columbus, OH 43210

<sup>4</sup>Department of Mathematics, The Ohio State University at Marion, 1461 Mount Vernon Ave, Marion, OH 43302

<sup>5</sup>Mathematics Department, The Ohio State University at Marion, 1461 Mount Vernon Ave, Marion, OH 43302

<sup>6</sup>Great Oaks Career Campuses, 110 Great Oaks Drive, Cincinnati, OH, 45241

<sup>7</sup>University of Mount Union, Alliance, OH, 44601

### I. INTRODUCTION

Recent years have seen an explosion of interest in analyzing the motion of objects in video data as a way for students to connect the concepts of physics to something tangible like a video recording of an experiment [1, 2]. The limitations of distance learning during the COVID-19 pandemic especially grew interest in this area because students could not attend in person lab activities, but they could analyze video data from their computers at home, which is what many instructors chose to focus on.

Generally, the goal of a student activity involving analysis of video data is to obtain the x,y position of a particular object in as many frames of the video as possible. Once obtained, this data can be used to infer velocities, acceleration and any number of other quantities like momentum or energy. A variety of software exists for students to look at individual frames

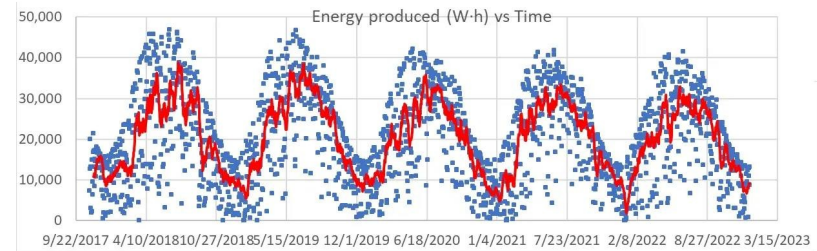
Video to analyze a video where he is walking across the sidewalk [2]. In the analyzed video, Dr. Lane has a red piece of paper taped to his right shoulder. This piece of paper is the object being tracked.

In the video tutorial, Dr. Lane explains that it is important to define the "template image" of the object not at the center of the paper but rather at one of the corners so that the object tracking algorithm searches for a splotch of red next to some gray, which is the color of his shirt. With this hint, the object tracking works well and the plot of x versus time shows that Dr. Lane is walking at an approximately constant velocity as expected.

Although this is just a brief moment in the tutorial video it underscores the difficulty of what automatic object tracking is attempting to do. The background of Fig. 1, for example, has many different features that the program potentially needs to scan through as it searches for the the red piece of paper.

# Other fun ideas

- Multi-year solar panel data
- Randomly generated star fields
  - Random number generator → csv file



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The screenshot shows a web browser window with the URL <https://www.asc.ohio-state.edu/orban.14/stemcoding/star/stars.html>. The page title is "Night Sky Simulator!". It features a woman on the left and a man on the right standing in front of a black square representing a star field. The text on the page includes: "The image above is not a real star field (maybe you've already no... night sky from a computer-generated star field. We are going to learn a little bit about stars and stars appear brighter... means.", "An interesting thing about... able to download a spreadsheet with the list of... we will use Google sheets... you can use any spreadsheet program you are comfortable with... the directions here... (Apple - Numbers)", "Step 0. Open up a simulator", "Click on this link to open a... Apollo moon landing code in a code editor", "Very Important: Sign in... click 'Duplicate' so you can have your own version", and "Press play there to run the...". A CCAPP logo is visible in the bottom right corner.

# Activity Links

Earth Day

[go.osu.edu/earthdaycoding](https://go.osu.edu/earthdaycoding)

Air Pressure

[go.osu.edu/airpressure](https://go.osu.edu/airpressure)

Object Tracker

[go.osu.edu/objecttracker](https://go.osu.edu/objecttracker)

works best w/ Chrome or Edge

[go.osu.edu/objecttracker-guide](https://go.osu.edu/objecttracker-guide)

STEM coding

# How you can help!

- Join the STEMcoding monthly email list and/or slack
  - Email [orban@physics.osu.edu](mailto:orban@physics.osu.edu)
- Undergrad projects?
- Email **BAD** figures to [orban@physics.osu.edu](mailto:orban@physics.osu.edu)
- NSF Broader Impact
- Invite me to speak to local AAPT chapters via zoom!
- Help us use ChatGPT?

# Questions?

[orban@physics.osu.edu](mailto:orban@physics.osu.edu)

[youtube.com/STEMcoding](https://youtube.com/STEMcoding)

Monthly email list:

[u.osu.edu/stemcoding](https://u.osu.edu/stemcoding)

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