Big Connections in Good Problems

http://college.wfu.edu/education/wp-content/uploads/ncctm2014.pdf

Mathematics Education
Department of Teacher Education
Wake Forest University

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Predicting Baseball Production through Numerical Analysis - *Austin Love*

Watering your Lawn with a Sprinkler System - *Reema Doany*

Exponential Growth: Social Media - *Thomas Flood*

CSI Math - *Kalyn Wyckoff*

Questions or problems, please contact Dr. Leah McCoy <mccoy@wfu.edu>

Predicting Baseball Production through Numerical Analysis

Austin J. Love III

Wake Forest University

Introduction:
Before a season ends in professional sports, teams begin to evaluate players that will be available in the offseason. During this process team executives and coaches analyze many different representations of a player's ability. In baseball, where a large amount of statistics are collected, numerical analysis methods are utilized in making personnel decisions.

Common Core Standard:
N.Q Reason quantitatively and use units to solve problems

Standards for Mathematical Practice:

- MP1 Make sense of problems and persevere in solving them
- MP2 Reason abstractly and quantitatively
- MP3 Construct viable arguments & critique the reasoning of others

Objectives:

- Collect the necessary data to complete the table
- Solve given equations to assist in player selection
- Examine all the data collected to determine most productive player
- Defend your selection using specific data as a reference

Learning Activities: Students will be given six professionals major league baseball players and will use the web to find the necessary statistics to complete the table. After completing the table students will solve the equations for slugging percentage, on base percentage and OPS. Using the information obtained groups will discuss and decide which player will be the most productive during the next season. Using specific data as a reference, groups will write a brief news article summarizing their choice and containing a statement as owners of a team signing the player to a contract.

Assessment: Groups will turn in completed worksheets and share their media statement release with the class.

It is the end of the 2013 season. You and your partners have recently purchased a Major League Baseball team. Unfortunately the team you have purchased finished in last place in 2013. The team you inherited severely underachieved offensively this past season. In Order to address your team's offensive needs you **MUST** sign a top offensive free agent. The following players are the top free agents being recruited in the 2013 offseason. Select six players to evaluate that you might potentially sign.

- Robinson Cano
- Jacoby Ellsbury
- Brian McCann
- Shin-Soo Choo
- Ben Zobrist
- Carlos Beltran
- Nelson Cruz
- Mike Napoli
- Coco Crisp
- Jarrod Saltalamacchia

Using www.mlb.com and baseball-reference.com complete the table on the next page to assist you in your selection of which player to sign.

The following statistics are needed to complete the table:

AB – At Bats

R – Runs Scored

RBI – Runs Batted In

H – Hits

1B - Singles

2B – Doubles

3B – Triples

HR – Homeruns

SB – Stolen Bases

BB – Walks

TB – Total Bases

HBP – Hit By Pitch

SF – Sacrifice Flies

PLAYER	AB	R	H	2B	3B	HR	RBI	SB	BB	TB	HBP	SF

1. Which statistics should you considered most for offensive production?
2. What statistics are similar?
3. Batting Average, Slugging Percentage, and On Base Percentage are other stats used to evaluate player performance. Using data collected complete the following equations and insert them into the table below.

Batting Average = $\frac{H}{AB}$ 1B = $H - 1B - 2B - 3B - HR$

On Base% = $\frac{(H+BB+HBP)}{(AB+BB+HBP+SF)}$ Slugging % = $\frac{(1B+2*2B+3*3B+4*HR)}{AB}$

PLAYER	BA	SLG%	OBP

STUDENT WORKSHEET PAGE 3

Based on your analysis of your finding which player do you believe will be the most productive next season? Justify using statistics collected?

As a group write a statement to be submitted to the media outlet of your chosen. Your statement should address why you selected this player and include information about his offensive production and expectations for the coming season.

SAMPLE COMPLETED PROJECTS

1. Which statistics should you considered most for offensive production? *Homeruns, RBI's, R, and SF.*
2. What statistics are similar? Why? *BB, HBP. Because in both cases you are only given one base.*
3. Batting Average, Slugging Percentage, and On Base Percentage are other stats used to evaluate player performance. Using data collected complete the following equations and insert them into the table below.

Batting Average = $\frac{H}{AB}$ 1B = $H - 2B - 3B - HR$

On Base% = $\frac{(H+BB+HBP)}{(AB+BB+HBP+SF)}$ Slugging % = $\frac{(1B+2*2B+3*3B+4*HR)}{AB}$

PLAYER	BA	OBP	SLG%
Robinson Cano	*.314*	*.383*	*.516*
Jacoby Ellsbury	*.298*	*.355*	*.426*
Brian McCann	*.256*	*.336*	*.461*
Shin-Soo Choo	*.285*	*.423*	*.462*
Ben Zobrist	*.275*	*.354*	*.402*
Carlos Beltran	*.296*	*.339*	*.491*

Based on your analysis of your finding which player do you believe will be the most productive next season? Justify using statistics collected? *Robinson Cano will be the most productive. In this group on players he finished first in almost every stat. Mainly looking at HR, RBI, R, and H, should make him the choice to be most productive.*

STATEMENT RELEASE

As a group write a statement to be submitted to the media outlet of your chosen. Your statement should address why you selected this players and included information about his offensive production and expectations for the coming season.

Via theownership@twitter.com

"Today we announce the signing of Robi Cano to our team. His HRs & high RBI total makes him a perfect fit. We expect similar totals next year."

Teacher Tips: Materials needed are computer with internet access and calculators if needed. Information related to top free agents can be found at www.mlb.com or www.espn.com. Statistics from previous seasons can be found at http://www.baseball-reference.com/. Later you can build on this activity using other baseball specific formula such as runs created, or Pythagorean Equation (formula to predicted winning percentage). Some baseball sabermetric equations can also be applied to other sports and can be found on the internet searching sabermetrics or Bill James.

Watering your Lawn with a Sprinkler System

Reema Doany
Wake Forest University

Introduction: You have a lawn that needs to be watered. You want to set up a sprinkler system so that you do not need to water it all by hand. If there is any area of the lawn that the sprinklers do not reach, you must water that area by hand. You must determine strategies for setting up sprinklers to maximize the area of the lawn that is watered by the sprinkler system. This task involves problem solving and several different types of geometric knowledge; finding areas of circles and sectors of circles, using trigonometric ratios and the Pythagorean theorem to solve right triangles.

Common Core Standards:

- CCSS 7.G.4 Know the formulas for the area and circumferences o a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.
- CCSS 8.G.7 Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.
- CCSS G-SRT.8 Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.
- CCSS G-MG.3 Apply geometric methods to solve design problems.

Standards for Mathematical Practice:

#1. Make sense of problems and persevere in solving them.
#6. Attend to precision.

Objectives:

- Students will be able to determine the area of the lawn covered by a sprinkler with radius 8m/two overlapping sprinklers with radius 8m.
- Students will be able to identify the most effective way to water the grass with two sprinklers placed on the corners of the lawn by using various geometric methods and justify their answer with calculations and explanations.
- Students will be able to form conclusions regarding the most efficient way to water the entire lawn of size 10m by 12m with 8m radius sprinklers.

Learning Activities:

Students will be given an in class project to work on in pairs.

See Handout.

Assessment: Write a short report outlining which corner strategy you chose and why. Explain the positive and negative components of choosing the optimal corner strategy or the optimal strategy in which sprinklers are placed in the interior of the lawn; you may mention the proportion of grass that is watered through the sprinkler system versus by hand, the costs associated with purchasing each sprinkler, and the convenience of the location of the sprinklers on the lawn.

Teacher Tips: When students are writing their reports, encourage them to think about the real-world implications of a sprinkler system. For instance, have them mention costs for each sprinkler they plan to purchase, the amount of water that would be needed with multiple sprinklers, the amount of water that would be wasted watering area outside of the designated lawn with a sprinkler on the edge of the lawn, and the convenience of the location of the sprinkler. For example, if it is in the center of the lawn, it is more likely that it will be stepped on or run over by a lawn mower. For advanced students, consider assigning additional problems that involve different shaped lawns. For example, L-shaped lawns, triangular lawns, circular lawns, or lawns that need to be broken up into a combination of these shapes.

Name: _____ Date: _____

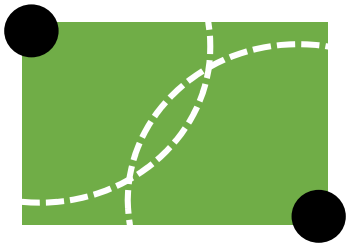
Watering your Lawn with a Sprinkler System

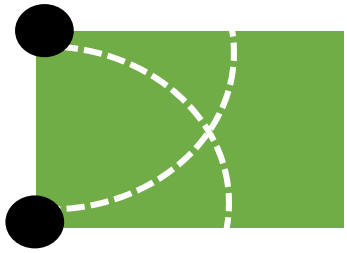
Background:
You have a 10m by 12m lawn that needs to be watered regularly. You currently water the entire lawn by hand and would like to install a sprinkler system to water it automatically. If there are areas of the lawn that are not covered by the sprinklers, you must water that area by hand. The sprinklers you are planning on purchasing can water grass within an 8 meter radius. You get to choose how many sprinklers you purchase and where they should be located on your lawn.

Part 1:
You have decided to purchase two sprinklers and place them at corners of the lawn so that they are out of the way. You can either place the two sprinklers at (1) opposite corners of the lawn, (2) two corners on a 12m side of the lawn, or (3) two corners of a 10m side of the lawn.

(1) (2) (3)

1. Can you water the entire lawn with any of these strategies? *Explain why or why not and show your work.*





2. Which of these strategies appears to be the best? *Justify your answer with calculations and explanations.*

3. By choosing the best of these three strategies, what percentage of the lawn will you be able to water with the two sprinklers? How much grass will have to be watered by hand with this strategy?

Part 2:
If you decide to place sprinklers in the interior of the lawn instead of the corners, how many sprinklers would you need to water the entire lawn? *Justify your answer with calculations.*

Part 3: *Report*
Write a short report outlining which corner strategy you chose and why. Explain the positive and negative components of choosing the optimal corner strategy verses the optimal strategy in which sprinklers are placed in the interior of the lawn; you may mention the proportion of grass that is watered through the sprinkler system versus by hand, the costs associated with purchasing each sprinkler, and the convenience of the location of the sprinklers on the lawn. *Type your response to these questions.*

Name: _____Answer Key_____ Date: _____

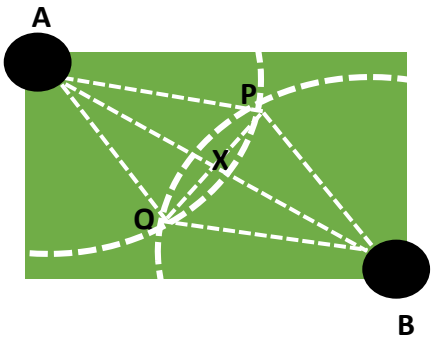
Watering your Lawn with a Sprinkler System

Background:
You have a 10m by 12m lawn that needs to be watered regularly. You currently water the entire lawn by hand and would like to install a sprinkler system to water it automatically. If there are areas of the lawn that are not covered by the sprinklers, you must water that area by hand. The sprinklers you are planning on purchasing can water grass within an 8 meter radius. You get to choose how many sprinklers you purchase and where they should be located on your lawn.

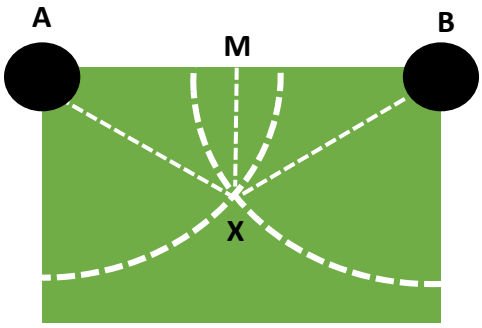
Part 1:
You have decided to purchase two sprinklers and place them at corners of the lawn so that they are out of the way. You can either place the two sprinklers at (1) opposite corners of the lawn, (2) two corners on a 12m side of the lawn, or (3) two corners of a 10m side of the lawn.

(1) (2) (3)

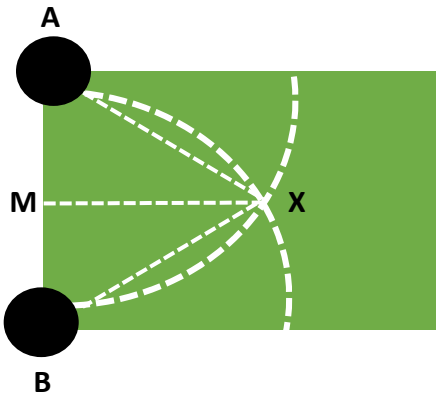
1. Can you water the entire lawn with any of these strategies? *Explain why or why not and show your work.*



- Each sprinkler covers a 90-degree sector of a circle of radius 8 meters. The areas covered by the two sprinklers overlap.
- Let A and B be two opposite corners of the lawn, let P and Q be the two points at which quarter-circles of radius 8 meters centered at A and B intersect, and let X be the point at which the segments AB and PQ intersect.
- Decompose the area covered into the rhombus APBQ and four circular sectors. The length of the diagonal AB is ~15.6 meters by the Pythagorean Theorem, so AX=7.8 meters.
- Since AP=8 meters, by the Pythagorean Theorem, PX= $\sqrt{8^2-7.8^2}$ meters, and thus PQ = 2 (PX) = ~3.6 meters. So the area of rhombus APBQ is A= ½ *AB*PQ = **~28.08 m².**
- Since m<PAX = arccos 7.8/8, the measure of angle PAQ= 2arccos 7.5/8 = ~25.7 degrees. So the two sectors of circle A not covered by the rhombus add up to a 64.3 degree sector of a circle of radius 8 meters. The same is true of the two sectors of circle B not covered by the rhombus, so the remaining area is equivalent to approximately a 128.6 degree sector of a circle of radius 8 meters. Area = ~ 128.6/360 *π*8² = **~71.8m².**
- So the total area covered by the sprinklers in this case is 28.08 + 71.8 **= 99.88 square meters, or about 83% of the lawn.**



- Each sprinkler covers a 90-degree sector of a circle of radius 8 meters. The areas covered by the two sprinklers overlap.
- Let A and B be opposite ends of the 12-meter side of the lawn where the sprinklers are placed. Let X be the point where the two quarter-circles of radius 8 meters centered at A and B intersect, and let M be the foot of the perpendicular from X to side AB.
- Decompose the area covered by the two sprinklers into the isosceles triangle ABX and two circular sectors. We know AM= 6 and AX=8, so by the Pythagorean theorem, XM= ~5.3. So the area of triangle ABX is approximately; A= ½ *XM * AB = ~ ½ *5.3*12 = **~ 31.8 m².**
- The measure of angle XAM is arccos 6/8 = ~41.4º. So the remainder of the covered area consists of two 48.6º sectors of circles of radius 8 meters. Each of these sectors has area A = (90-arccos (6/8))/360 *π*8² = **~27.2m².**
- So the total area covered is approximately 31.8 + 2 (27.2) = **86.2 square meters, or about 71.8% of the lawn.**



- Each sprinkler covers a 90-degree sector of a circle of radius 8 meters. The areas covered by the two sprinklers overlap.
- Let A and B be opposite ends of the 10-meter side of the lawn where the sprinklers are placed. Let X be the point where the two quarter-circles of radius 8 meters centered at A and B intersect, and let M be the foot of the perpendicular from X to side AB.
- Decompose the area covered by the two sprinklers into the isosceles triangle ABX and two circular sectors. We know AM=5 and AX=8, so by the Pythagorean Theorem, XM=~6.2. So the area of triangle ABX is approximately, A= ½ *XM * AB = ~ ½ *6.2*10 = **~ 31 m².**
- The measure of angle XAM is arccos 5/8 = ~51.3º. So the remainder of the covered area consists of two 38.7º sectors of circles of radius 8 meters. Each of these sectors has area A = (90-arccos (5/8))/360 *π*8² = ~**21.6m².**
- So the total area covered is approximately 31+2(21.6) **= 74.2 square meters, or about 61.8% of the lawn.**

2. Which of these strategies appears to be the best? *Justify your answer with calculations and explanations.*

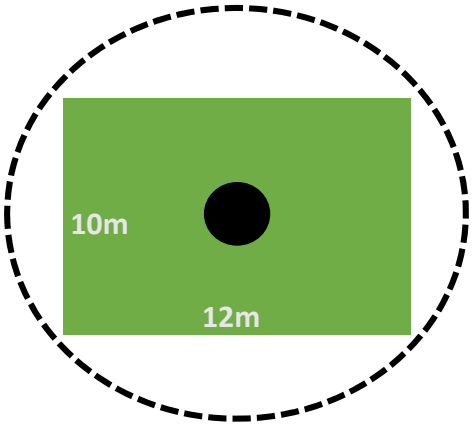
Strategy (1) with the two sprinklers at opposite sides of the lawn appears to be the best. This strategy waters 99.8 square meters (83%) of the lawn, compared to 86.2 square meters (71.8%) and 74.2 square meters (61.8%) of the lawn when the sprinklers are on two corners of the same side of the lawn.

3. By choosing the best of these three strategies, what percentage of the lawn will you be able to water with the two sprinklers? How much grass will have to be watered by hand with this strategy?

With strategy (1) where the sprinklers are at opposite sides of the lawn, you will be able to water approximately 83% of the lawn with the sprinklers. This leaves 17% to be watered by hand; 120*.17 = 20.4m. Therefore, 20.4m will need to be watered by hand with this strategy.

Part 2:
If you decide to place sprinklers in the interior of the lawn instead of the corners, how many sprinklers would you need to water the entire lawn? *Justify your answer with calculations.*

Suppose you place one sprinkler in the center of the lawn. The diagonal of the rectangle is $\sqrt{10^2+12^2} = \sim 15.6$ meters. The distance from the center of the lawn/sprinkler to each corner is ~7.8 meters, which is less than the sprinkler's reach. Since the corners of a rectangle are the points farthest form the center, one sprinkler placed in the center can water the entire lawn.



Part 3: *Report*
Write a short report outlining which corner strategy you chose and why. Explain the positive and negative components of choosing the optimal corner strategy verses the optimal strategy in which sprinklers are placed in the interior of the lawn; you may mention the proportion of grass that is watered through the sprinkler system versus by hand, the costs associated with purchasing each sprinkler, and the convenience of the location of the sprinklers on the lawn. *Type your response to these questions.*

Exponential Growth: Social Media

Thomas Flood

Introduction: In media and culture, the term "exponential growth" is often used to describe rapid growth. One such usage has been to describe the rapid growth in celebrity's social media followers. But do individuals who use this term understand what exponential growth truly means? This lesson is designed to teach students to build exponential functions from real data, graph these functions, and test their models for validity. It is designed to take up one class period.

Common Core Learning Objective:

F-LE.2: Construct linear and exponential functions, including arithmetic and geometric sequences, given a graph, a description of a relationship, or two input-output pairs (include reading these from a table).

N.Q: Reason quantitatively and use units to solve problems.

Mathematical Practice Standards:

#3: Construct viable arguments and critique the reasoning of others.

#4: Model with mathematics.

#7: Look for and make use of structure.

Specific Objectives:

SWBAT model exponential functions from two data points

SWBAT check and discuss the validity of a an exponential model using other data points

Lesson Outline:

- Students will pick a favorite celebrity social media account (Twitter, Instagram, possibly other)
- Students will use the site Wayback Machine (http://archive.org/web/) to find historical data on the number of followers their celebrity had at a number of times
- Using current data and the first data point available, students will create an exponential function to model the celebrity's follower growth over time
- Students will graph their models using Desmos & print
- Using 5 other data points, students will check the validity of their model (by graphing and using the function)
- As a class, students and teacher will discuss if the models fit or if other models might fit better.

Assessment:

Students should turn in worksheets and graphs to be checked for accuracy. Class discussion will also provide opportunity to assess how well students understand modeling exponentially.

Exponential Modeling: Twitter Followers

Examples:

Lady Gaga	Justin Bieber	Katy Perry	Harry Styles
Barack Obama	Selena Gomez	Taylor Swift	Arianna Grande
Rihanna	Adele	Ellen DeGeneres	Oprah Winfrey

My celebrity is: _____

Data Points: Include current data, earliest data, and 5 points between

Number of Followers							
Date							
Time Elapsed							

Using the formula for exponential growth, create a model for growth using current and earliest data. Graph your model on graph paper.

$Y = Pb^t$

Now, plot the other 5 data points you found on your graph and check them in the function. Does this model seem to fit? Are there other models that might fit better? Do exponential functions model correctly over any time period?

Exponential Modeling: Twitter Followers

Example Work

My celebrity is: Barack Obama

Data Points: Include current data, earliest data, and 5 points between

Number of Followers	23	5239	13509	5.8 mil	18.2 mil	40.3 mil	48.8 mil
Date (Month/Year)	3/07	11/07	3/08	11/10	8/12	12/13	10/14
Time Elapsed (Months)	0	7	12	44	65	81	91

Using the formula for exponential growth, create a model for growth using current and earliest data. Graph your model.

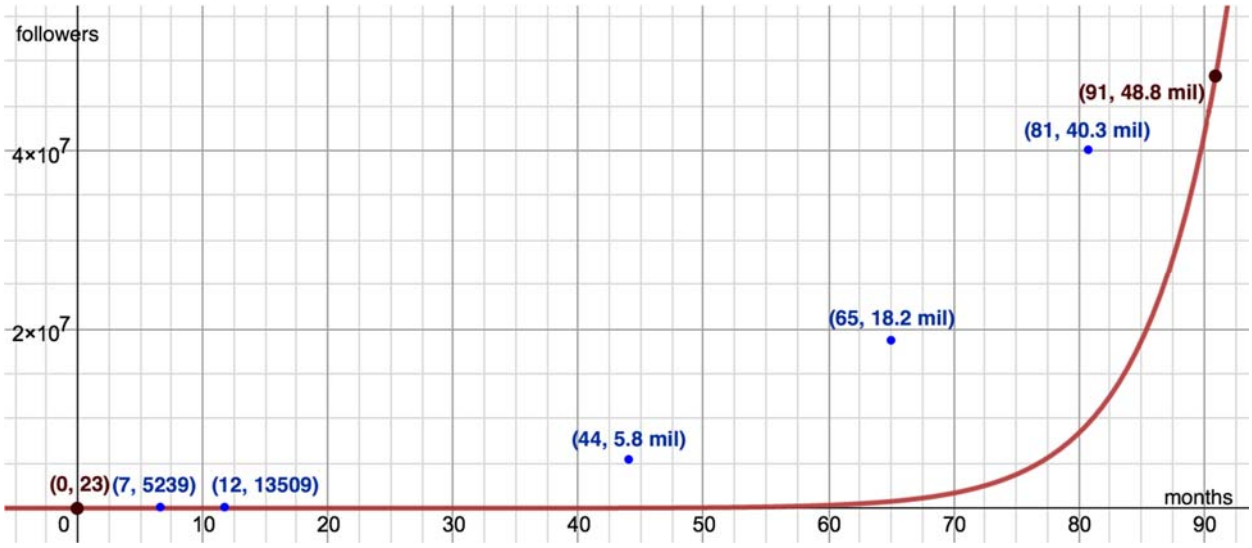
$Y = Pb^t$

$48{,}800{,}000 = (23)b^{91}$

$2{,}121{,}739.13 = b^{91}$

$b = 1.1736$

$Y = (23)(1.1736)^t$



Now, plot the other 5 data points you found on your graph and check them in the function. Does this model seem to fit? Are there other models that might fit better? Do exponential functions model correctly over any time period?

$Y = (23)(1.1736)^7 \sim 71$	vs.	(7, 5,239)
$Y = (23)(1.1736)^{12} \sim 157$	vs.	(12, 13,509)
$Y = (23)(1.1736)^{44} \sim 26{,}340$	vs.	(44, 5.8 mil)
$Y = (23)(1.1736)^{65} \sim 759{,}512$	vs.	(65, 18.2 mil)
$Y = (23)(1.1736)^{81} \sim 9.8 \text{ mil}$	vs.	(81, 40.3 mil)

Graphically, it looks like the model holds at first then digresses. But when comparing points in the function, we see the model does not fit well even at the beginning. Over this time period, it doesn't appear as if President Obama's followers grew exponentially. The model should rise more quickly earlier then flatten out. A degree-3 polynomial function may fit better. Over shorter time periods, an exponential curve may have fit.

Teacher Tips

Discussion:

In the discussion that follows filling out the worksheet, there are a number of considerations teachers should keep in mind. Most students will have found that their models do not fit. This lends itself to a discussion about the common misuse of the term "exponential." It is also important to note the trouble with graphical representation of the model. Since we are working with such large numbers, on the graph it appears as though the first few data points corroborate the graph. However, this is not the case when the points are plugged into the function. Students should make note of the pitfalls of relying just on graphs.

Possible Discussion Questions:

Are the celebrity followers growing exponentially?

Why is the term 'exponentially' used commonly and incorrectly?

Are there other functions that may model the growth better?

Would the exponential model work over a particular period of time?

If followers were growing exponentially, what would that mean for future growth?

Why is expecting growth to follow exponential patterns problematic?

Differentiations:

This activity could be done individually or in groups.

By using different time units (years, months, weeks, etc.), students can alter how challenging and deep the models become. Teachers could encourage the use of a particular unit or allow students to use whichever they want. It may be helpful to students to show that the use of different units creates approximately the same graph (but that the more specific the unit, the more precision the model allows)

This example was done with Twitter, but just about any social media tool could work, as long as the data could be collected.

There is also potential for further investigation beyond this lesson. While the entire time period may not be modeled exponentially, it is likely that a smaller time period around when the celebrity got famous might fit along an exponential curve. By creating different models using different data points, students may try to find a model that fits more accurately. This could be homework or a future activity.

Important Links:

Desmos https://www.desmos.com/calculator

Wayback Machine http://archive.org/web/

CSI Math

Kalyn Wyckoff
wyckka14@wfu.edu

Introduction

In law enforcement, math is used to solve a variety of different crimes. Logarithms are used to find time of death, inverse tangents to find height of shadows, proportions to find characteristics about the suspects and many formulas to find speed, distance and time. In the following exercise, students step into the role of a law enforcement officer attempting to solve a robbery.

Common Core State Standards

SSE-A.1 Interpret expressions that represent a quantity in terms of its context
N-Q Reason quantitatively and use units to solve problems
A-REI.3 Solve linear equations and inequalities in one variable, including equations with coefficients represented by letters.
MP.1 Make sense of problems and persevere in solving them
MP.6 Attend to precision

Goals

- Understand how mathematical equations can be used to solve real-world problems
- Recognize which information is important to solve a problem and be able to input values to solve an equation
- Use proportions to relate information and solve for unknown information.
- Understand the real-world application of inequalities

Activities

In order to identify who robbed a local convenience store, the students must complete three different tasks. In order to figure out which type of car was used in the robbery, tire tread marks must be measured by hand and put into a formula to see which type of car was going the same speed as the robber's car. The students determine how far the robber could have possibly gone by car and compare these calculations to streetlight footage within the area to determine if the car was caught on video. The students also compare stride length to determine the possible height of the robber. All these calculations together reveal the person who committed the robbery. The students will have to calculate the speed of the cars, the maximum distance traveled of the cars and the characteristics of the robber on a worksheet provided. This can be used as a form of assessment, as well as if they were able to deduce which person committed the crime. At the end, the students will have to explain why they are sure the identified criminal committed the crime to a local newspaper using mathematical evidence.

CSI Math

There's been a robbery at the local grocery store in Winston-Salem and you are the first police officer on the scene. You need to figure out who the robbers are within the next hour and a half so the criminals don't cross state lines before putting a warrant out for their arrest. You have a variety of information from the crime scene that will help you in this investigation including tire marks, streetlight footage, footprints and witness accounts. In order to find the criminals, you must piece all of this information together to identify a suspect.

Evidence 1: Tire Marks

In the parking lot of the local supermarket, there are many tire marks from people skidding to a stop. Due to witness accounts and streetlight footage, it is estimated that the robbers were going approximately 50 miles per hour in a blue car when they skidded to a stop to begin the robbery. You need to examine the skid marks in the parking lot to determine which tire marks came from a car going from 48-52 miles per hour at the time it stopped. Then, compare the correct tire marks to the tire treads of each type of car to determine which car the robbers were driving.

The speed of a car when it comes to a complete stop can be measured by the length of its tire marks. The equation is:

$$S = 15.9\sqrt{df}$$

where S is the speed of the vehicle, d is the distance of the skid marks in feet (inches will be used for this exercise), and f is the coefficient of friction. In order to find the coefficient of friction, we must use the following equation:

$$f = \frac{F}{W}$$

where f is the coefficient of friction, F is the force of gravity coming down on the tires, and W is the weight of the tire. Set $F = 4$.

Use the table on the "Police Findings" page to record all your data. Use the tire tread marks and the car information on your group's table to find the length of the tread marks, the coefficient of friction and speed of each car at the time they stopped. Then, use this information to find the speed the cars were going at the time they stopped. Once you have identified which tire marks went the speed of the suspect's car, deduce which tires, and therefore which car, may have belonged to the suspect. Be careful: there may be more than one answer.

Evidence 2: Maximum Distance Traveled

The robbers left the local supermarket at exactly 4:30:00 pm. Streetlight cameras at six intersections were used to determine which blue cars of the correct witness description passed the light within half an hour. The GPS map gives you the distance from the local supermarket to each stoplight. It also gives you the exact time each of the cars passed the stoplight. Assume, given traffic patterns at the time the robbers traveled, that the robbers could drive around 50mph on average. Which of the stolen license plates caught on camera could be that of a possible suspect? Record the possible time window of the cars passing the lights. Use the formula:

$$r \times t = d$$

where r is the rate, t is the time in, and d is the distance. Be careful when converting hours to minutes and minutes to seconds when evaluating the time it took to get to each stoplight. There will be more than one possible stolen license plate that belongs to the culprit.

Evidence 3: Stride Length vs. Height

At the crime scene there are three sets of footprints that could possibly belong to the robber. You are given the average stride length of the robber's footprints, which is located on the "Police Findings" sheet. There is a common relationship between stride length and the height of a person. When you divide stride length by height, the common ratio is usually anywhere between .41 and .45. Knowing this information, use your knowledge of the suspects' height to determine whether he or she could be the person who committed the robbery. The equation that you should use to interpret the information is below. Make sure that you record the possible upper and lower bounds of their heights.

$$.41 < \frac{Stride\ Length}{Height} < .45$$

Once you identify the possible heights of the robber, compare this information to the heights of the suspects located on the "Suspect Profile" sheet. You should be able to eliminate suspects based on this information.

Identifying the Culprit:

After you identify the type of car the robber drove, the stolen license plate of the car and the possible suspects of the robbery, I will show you a table with information from the streetlight footage needed to identify the criminal. If you made all your calculations correctly, you should be able to figure out the culprit based on your information. After you have identified the criminal, write a statement for the local newspaper explaining how you are sure you have the correct suspect based on your calculations. This information may be used in court at a later date.

Police Findings

Evidence 1:

Car Type	Length of Tread Marks	Coefficient of Friction Equation	Coefficient of Friction	Speed of Car Equation	Car Speed	Possible Suspect?
The Blue Blanket						
The Blue Panther						
The Smarty Pants						
The Smurfmobile						
The Blue Rocket						
Mr. Blueberry						

Evidence 2:

Stolen License Plate #	Possible Rate of Car	Distance of Stoplight	$r \times t = d$	t	Time to stoplight (mins)	Possible time range	Possible Suspect?

Problem Work Area:

Evidence 3: Stride Length and Height

Stride Length	Upper Bound Equation	Upper Bound (inches)	Lower Bound Equation	Lower Bound (inches)
24 inches				
27 inches				
32 inches				

Suspect Name	Height (inches)	Possible Suspect?
Judy Green		
Johnny Appleseed		
Leslie Snap		
Lionel Frost		
Margaret Penny		
Edgar Easel		

Local Newspaper Statement:

Teacher Tips:

The following tables give the answers to the data presented in the scenario and the work for each of them. Above each table there are tips about how to change the material to better suit your students and things for the students to remember when doing calculations. It also mentions the setup involved to do the particular activity.

Evidence 1: The following table uses the information about the weight of the tire, the force of gravity and the distance of the skid marks to figure out which cars were going between 48 and 52mph when they skidded to a stop. To set up for this activity, you need the car and tire information on page 9 and to create skid marks of the proper tire pattern. The distance in inches of the tire marks necessary are listed below:

1. The Blue Blanket: 18 inches
2. The Blue Panther: 58 inches
3. The Smarty Pants: 26 inches
4. The Smurfmobile: 57 inches
5. The Blue Rocket: 45 inches
6. Mr. Blueberry: 55 inches

The tire marks can be created through drawing them on banner paper or taping together the tire marks that are provided in the appendices (page 12). All the tire marks are different enough to complete through drawings and have the students identify which tire marks belong to which car easily. Once the students have identified which tire marks went the speed of the suspect's car, they can deduce which tires, and therefore which car, may have belonged to the suspect.

Car Type	Coefficient of Friction Equation	Coefficient of Friction	Speed of Car Equation	Car Speed	Possible Suspect?
The Blue Blanket	$f = \frac{4}{20}$	.2	$15.9\sqrt{(.2)(18)}$	30.2	No
The Blue Panther	$f = \frac{4}{22}$	.182	$15.9\sqrt{(.182)(58)}$	51.7	Yes
The Smarty Pants	$f = \frac{4}{18}$	.222	$15.9\sqrt{(.222)(26)}$	38.2	No
The Smurfmobile	$f = \frac{4}{19}$	.211	$15.9\sqrt{(.211)(57)}$	55.1	No
The Blue Rocket	$f = \frac{4}{25}$	.16	$15.9\sqrt{(.16)(45)}$	42.7	No
Mr. Blueberry	$f = \frac{4}{24}$	.167	$15.9\sqrt{(.167)(55)}$	48.2	Yes

Evidence 2: The table below outlines the time it would have taken for a car to travel from the local supermarket to each of the stoplights. To set up this station, you will need the stoplight data located on page 10. The students should compare the time it would have taken for a car to reach the stoplights from the supermarket and eliminate certain stolen license plates based on the time stamp. The students should be careful when converting hours to minutes and minutes to seconds.

Evidence 3: The table below outlines the possible heights of each of the subjects based on the stride lengths determined by the footprints at the crime scene. The students will have to interpret the inequalities and use proportions to solve for possible heights. The students should be careful when converting feet to inches and setting up their inequalities. For this station, you will need the suspect profiles located on page 11.

Stride Length	Upper Bound Equation	Upper Bound (inches)	Lower Bound Equation	Lower Bound (inches)
24 inches	$\frac{24}{Height} > .41$	$H < 58.5$	$\frac{24}{Height} < .45$	$H > 53.3$
27 inches	$\frac{27}{Height} > .41$	$H < 65.9$	$\frac{27}{Height} < .45$	$H > 60.0$
32 inches	$\frac{32}{Height} > .41$	$H < 78.0$	$\frac{32}{Height} < .45$	$H > 71.1$

Suspect Name	Height (inches)	Possible Suspect?
Judy Green	63	Yes
Johnny Appleseed	69	No
Leslie Snap	66	No
Lionel Frost	71	No
Margaret Penny	68	No
Edgar Easel	73	Yes

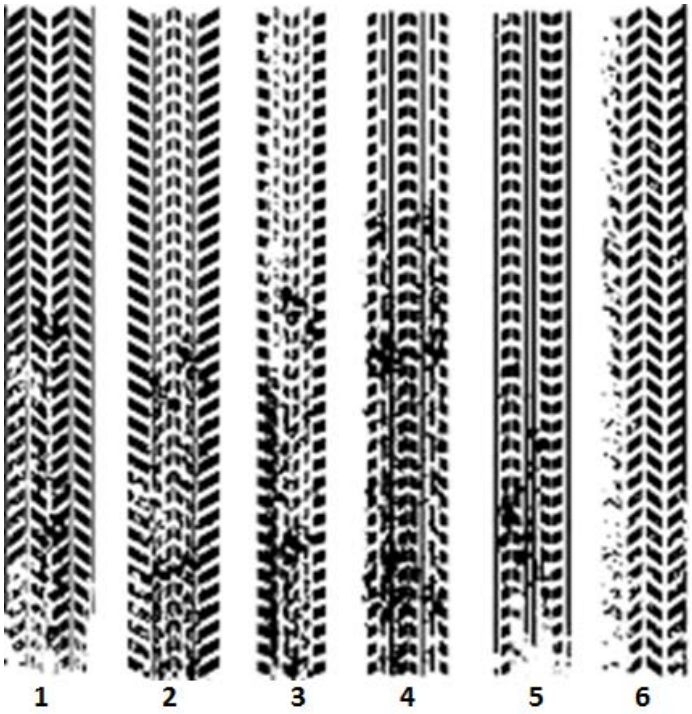
Who is the Criminal?

License Plate Number	Type of Car	Sex of Driver
CAR56Y	The Blue Panther	Female
HS48AK	Mr. Blueberry	Female
WNP376	Mr. Blueberry	Male
W29SH2	The Blue Panther	Male
AK74B9	The Smurfmobile	Female
KAP9472	The Blue Rocket	Male

Based on the information provided, the students should be able to deduce the culprit! After they finish their calculations, you should show them the table above without the highlighted answers and have them choose the culprit based on the possible subjects. They should obtain the answer that Judy Green was the culprit based on the correct license plate, correct type of car, and the sex of the driver. The students should then write a statement for the local newspaper explaining how they are sure they have the correct suspect based on their calculations.

Evidence 1: Tire Tracks

The following six tire patterns are those of the tire tracks found in the parking lot. The number under the tire pattern corresponds to the number of the car.



1. The Blue Blanket
   Tire Weight: 20 lbs

2. The Blue Panther
   Tire Weight: 22 lbs.

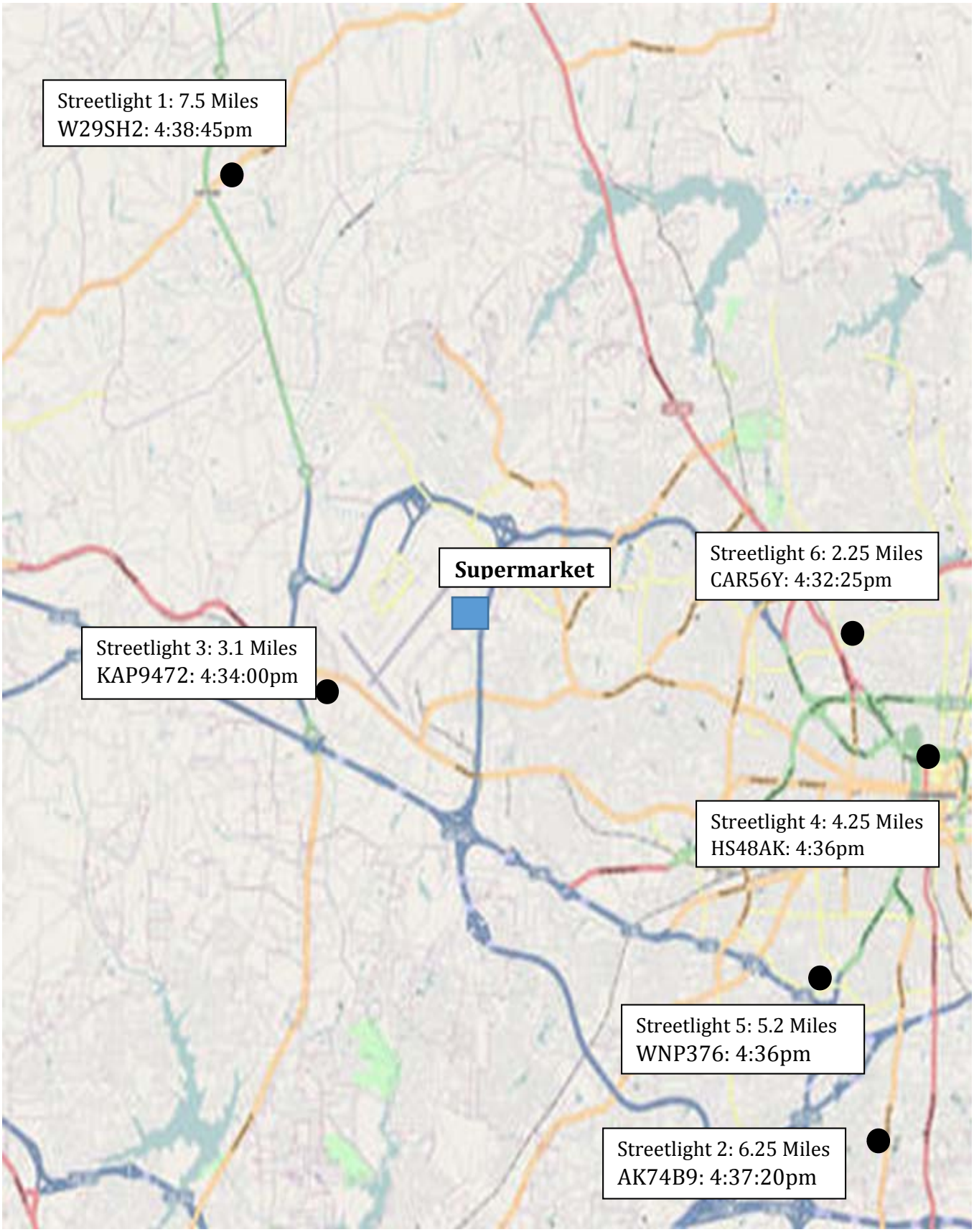
3. The Smarty Pants
   Tire Weight: 18 lbs.

4. The Smerfmobile
   Tire Weight: 19 lbs

5. The Blue Rocket
   Tire Weight: 25 lbs

6. Mr. Blueberry
   Tire Weight: 24 lbs.

Evidence 2: Streetlight Data



Evidence 3: Suspect Profiles

Name: Judy Green

Height: 5’ 3”

Name: Johnny Appleseed

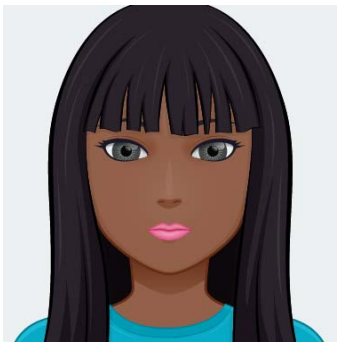
Height: 5’ 9”

Name: Leslie Snap

Height: 5’ 6”

Name: Lionel Frost

Height: 5’ 11”

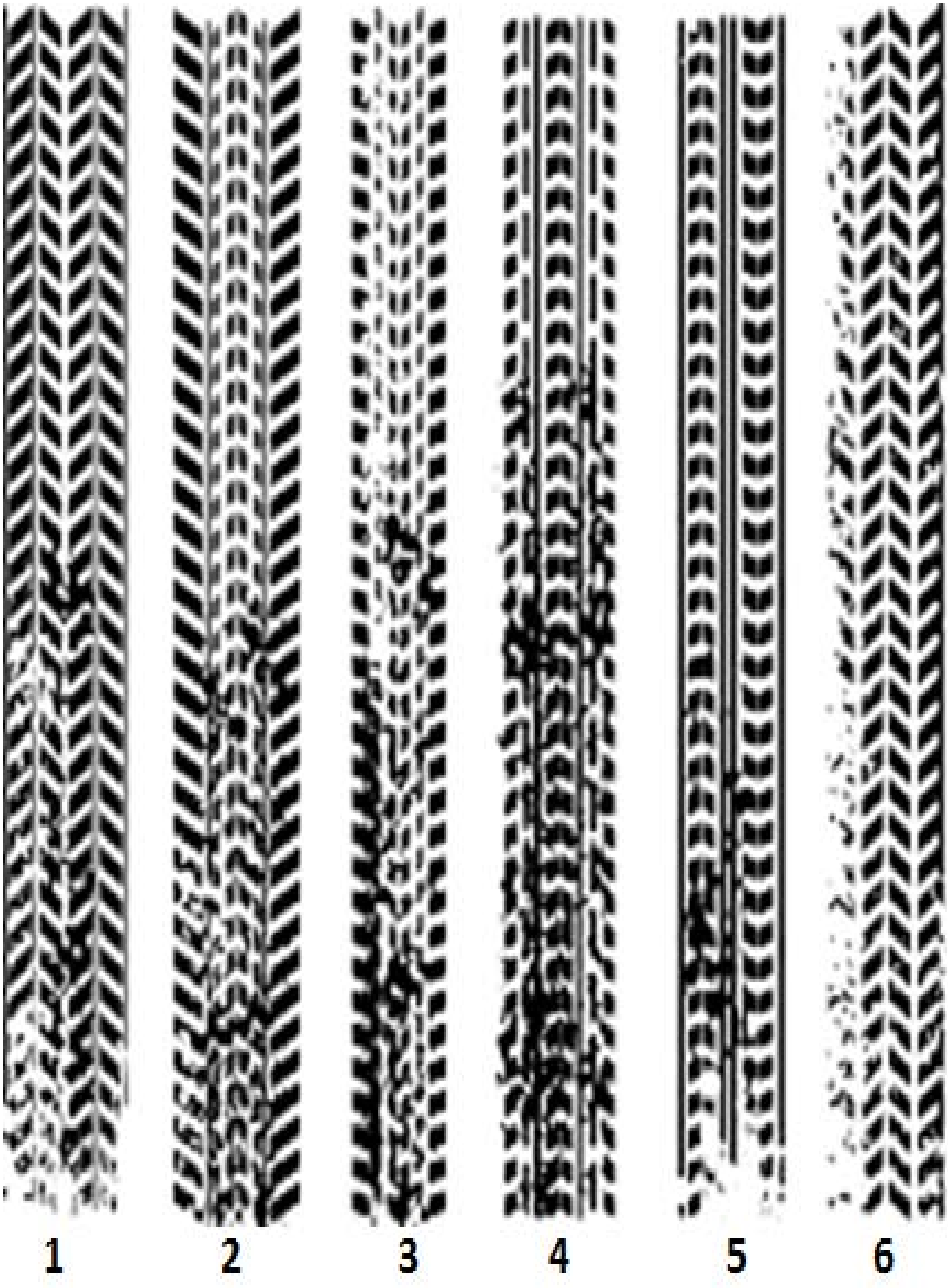


Name: Margaret Penny

Height: 5’ 8”

Name: Edgar Easel

Height: 6’ 1”


1
2
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