Time to Get a Job!

Presented by:

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Overview

- Purpose
- Math & Video Games
- Math & Police Work
- Math & the Environment
Math & Video Games

This project is best for Intermediate Algebra students.

Students will NOT:

• Need a coding class or background
• Become master video game architects
• Use this in their “every day lives” unless they become a programmer

Students WILL:

• Need basic knowledge of graphing coordinates, graphing and writing equations of parabolas, inequalities, and circles.
• Need basic knowledge of distance formula, Vertex Form of a quadratic function, finding the vertex of a quadratic function
• Gain a basic understanding of where and how math is used in real life and not just a homework problem
• Have fun!!
Getting them Excited!

- Introduce the project with a game:
  - Go to: https://scratch.mit.edu/projects/172584621/#player
The Project

- **Part One: Moving Your Character**
  - Distance Formula
  - Plotting Points

- **Part Two: Developing Boundaries**
  - Out of Bounds Zones - Graphing and writing Linear Inequalities

- **Part Three: Bad Guys**
  - Weapons - Graphing and writing Quadratic Equations
  - Hit Radius - Graphing and writing equations of circles

- **Part Four: Reflection**
  - What math was used?
  - Where else can this be used?
  - What about more advanced video games?
Downfalls of this Project

- Video Game Editor (scratch.mit.edu)
  - Due to the pixels not correlating with a standard graph and the actual working space on the video game area on scratch.mit.edu, couldn’t get the project to line up with the equations I chose.
  - Wanted students to be able to go into the project and change some numbers to see what happens to the parabola, etc, but the graphing space was too small.
  - Due to making this video game editor easily accessible to all, I sometimes had to use more logic based math than algebra to write the demo.
Math & Police Work
This project is designed for pre-algebra students

Students will combine various pre-algebra topics:

- Using ratio and proportions
- Finding percent
- Converting between measurements
- Using operations involving fractions
- Finding square root
- Using formulas

Added benefit:

Students will discover some of the many uses of algebra in daily police work
Grab Student’s Attention & They Want to Learn More

- Introduce the project by showing a video of actual police officers talking math:
  - Go to:
    - https://www.youtube.com/watch?v=z4x2mdtgaz0&index=5&list=WL
Using Math to Solve Crime

You are a detective for the Cambridge police. Last night, at approximately midnight, a burglar broke into a museum and stole many precious items. It is your job to look at the following information and solve the crime.

1. After looking at the security footage, you have the following information: A freeze frame shows the burglar measuring at 5 ft and a statue measuring at 7 ft. If the statue is actually 2.1 meters, what is the height of the burglar in meters? What is the burglar’s height in feet?

2. You find two different sets of prints at the crime scene. You don’t see an automatic on the video footage, but you do get a distinct fingerprint (see next page). Given that a person’s hand span (length from tip of thumb to tip of pinky) to their height is a 1:3 ratio, what is the second burglar’s height?

3. The average criminal travels 70 miles per hour on the freeway. From the museum, it takes at least a quarter of an hour to get to the freeway which is 5 miles away. If the burglars committed the crime 1/2 hour ago, how far have they most likely traveled? (remember: d = rt)

4. You send out a search radius using the above information. What is the perimeter of your search radius? How many square miles are you trying to cover? Use 2.34 for r.

5. The search for the crooks resulted in a high-speed chase that ended with a crash. You have to determine how fast the burglar was traveling before impact. Given the distance of a child mark, you can determine the velocity of a car using the formula \( v = \sqrt{2gh} \) where \( v \) = velocity (ft/sec), \( g \) = gravity (32.2 ft/sec^2), \( d \) = distance (ft), and \( h \) = height (0.75-false from testing similar car on similar surface). If the burglars’ car left a skid mark 250 feet long, first find the speed of the car before impact. Then use dimensional analysis to convert this to miles per hour (mph).

\( v = \) \( \) mph
6. On average, police solve no more than 12 crimes out of 100. What is the ratio of crimes solved to crimes committed? What percent of crimes are solved?
Student Response
Math & the Environment
for Intermediate Algebra Students

Part 1: Groundwater Levels
COURSE PROJECT – PART 1
Finding the Trendline Equation for Groundwater Levels
(Worth 25 points)

USGS

Depth to water level, feet below land surface

Elevation above NGVD 1929, feet

Years

Plot created: 1/1/2017 02:32
Part 1 Project Requirement

1) This part is worth 15 points, but work must be shown in order to achieve full credit. This means: (a) showing steps in how you obtained the slope (10 points), and (b) showing steps leading up to the equation itself (5 points). I need to be able to follow your work and penmanship/organization must be clean. Find the equation of the trendline, WRITTEN USING FUNCTION NOTATION (the best-fit straight line passing through the graph shown above). Hint: Have “zero” represent the year 1938, and have 15 represent the year 2012. Also, I recommend using the elevation data on the right-side y-axis for the y-values, since the depth to water level is in reverse from what you are used to seeing.
2) This part is worth 5 points, but work must be shown in order to achieve full credit. This means inputting the right value into the equation and showing steps as to how you got to your answer. I need to be able to follow your work and penmanship/organization must be clean. Using the equation you just derived, find the water level elevation for the year 2020. (Hint: If 15 represented the year 2012, what will you use to represent the year 2020?) You must use this equation to determine this value. Only use an extrapolation of the graph to check the accuracy of your answer.
3) This part is worth 5 points. You must answer using a short paragraph with complete sentences. Since I’m asking you for a paragraph, I need to see at least three complete sentences. What does this graph mean? Do you think this graph is an accurate representation of water levels throughout Utah Valley? Why or why not?
Part 2: Air Quality Index (AQI)
Computing the AQI

The air quality index is a piecewise linear function of the pollutant concentration. At the boundary between AQI categories, there is a discontinuous jump of one AQI unit. To convert from concentration to AQI this equation is used:

\[ I = \frac{I_{\text{high}} - I_{\text{low}}}{C_{\text{high}} - C_{\text{low}}} (C - C_{\text{low}}) + I_{\text{low}} \]

where:

- \( I \) = the (Air Quality) index,
- \( C \) = the pollutant concentration,
- \( C_{\text{low}} \) = the concentration breakpoint that is \( \leq C \),
- \( C_{\text{high}} \) = the concentration breakpoint that is \( \geq C \),
- \( I_{\text{low}} \) = the index breakpoint corresponding to \( C_{\text{low}} \),
- \( I_{\text{high}} \) = the index breakpoint corresponding to \( C_{\text{high}} \).
1) **This part is worth 25 points.** Solve the above-mentioned formula for $C_{low}$. You must show your work by including the following steps: (a) Clearing out the fraction (5 points), (b) distributing where necessary (8 points), (c) gathering terms with $C_{low}$ on one side of the equation and placing all other terms on the other side of the equation (8 points), (d) factoring out $C_{low}$ on one side of the equation (3 points), (e) writing the correct answer (6 points). I need to be able to follow your steps. (Hint: To make this easier on yourself, I recommend using different variables to represent those with subscripts. For example, let $w = C_{low}$, $x = C_{high}$, $y = I_{low}$, and $z = I_{high}$.) If I cannot follow your steps then no credit will be given for the entire assignment, so use good penmanship and keep things orderly!
2) This part is worth 5 points, but work must be shown in order to achieve full credit. This means showing: (a) the equation set up, with numbers properly substituted for variables (1 point), (b) simplification of the numerator (1 point), (c) simplification of the denominator (1 point), (d) the end result after division (2 points). Again, I need to be able to follow your steps and you must have good penmanship. Assuming the pollutant concentration is 51.0 micrograms per cubic meter, the high-end concentration breakpoint of 55.4.0 micrograms per cubic meter, the low-end index breakpoint of 101 micrograms per cubic meter, and the high-end index breakpoint of 150 micrograms per cubic meter, what would the low-end concentration breakpoint have to be in order to give an AQI of 139 micrograms per cubic meter? (Incidentally, the AQI for Orem, Utah on January 11, 2015 was 139 micrograms per cubic meter, which is categorized as “unhealthy for sensitive groups” by the EPA. Finding the low-end concentration breakpoint would help distinguish where the concentration breakpoint would have to be in order to upgrade to the “moderate” category of air quality.)
Part 3: Solid Waste
The following chart shows the amount of municipal solid waste and the recycling rates for the USA between the years 1960 – 2012. (Source: [www.epa.gov/sites/production/files/2015-09/documents/2012_msw_fs.pdf](http://www.epa.gov/sites/production/files/2015-09/documents/2012_msw_fs.pdf))
Your assignment: Find the exponential growth rate for the Total MSW Recycling curve (the one with the triangles). To do this, you will need the following formula:

\[ y = C(1 + r)^x \]

where

\( C = \) the initial amount  
\( r = \) the growth rate  
\( x = \) number of time intervals

Part 3 of the course project will be worth 30 points. You must show your work for full credit. There are several ways to get this answer, but you need to show your work and I need to be able to follow it. Don’t forget to write the answer as a percentage!

You can also get help from the math mentor xxxxxxx and the math tutor/environmental consultant xxxxxxxxx. Their emails are: xxxxxxxxxxx and xxxxxxxxxxx. However, do not wait until the day before the assignment is due to ask them for help. They are also students and have busy schedules as well.
MATH & Video Games

The graphics in video games evolved from a combination of computer programming and mathematics. At its most basic, we can think of a landscape in a video game as a two-dimensional coordinate plane.

Part one:
First, we want to be able to move our character around the plane. As the game designer, we can decide how far each press of the up/down/left/right button moves the character. Assume we decide that the up/down buttons move the character 3 units each time and the left/right buttons move the character 4 units.

1. If Mario always starts at the origin and a player pushed the following sequence: up, up, right, determine the coordinate where Mario ends up. ____________________________

2. What distance has Mario traveled? ____________________________ (Show ALL work below)

3. Plot Mario’s position on the graph on page 3 (label the point with an M).
Part two:
Now we want to develop the landscape with mountains. We do not want Mario to travel into the mountainous terrain. We define where Mario can travel by setting the out-of-bounds areas with inequalities.

1. Looking at the graph on page 3, write an inequality to represent the shading for the mountainous region. __________________________ (Show ALL work below)

2. Add another out-of-bounds mountainous region by graphing \( y \leq 5x - 60 \) on the same graph on page 3 (label at least 3 points on the graph).

Part three:
Video games usually contain a “bad guy” like Bowser found in Mario. Programmers can use linear or quadratic functions to shoot arrows, fireball, and other weapons at the main character.

1. Plot Bowser’s position at \((-10, -4)\) on your graph (label the point with a B).

2. Bowser shoots a fireball on the path of the equation:
\[
y = -\frac{1}{9}x^2 - \frac{2}{9}x + \frac{44}{9}
\]
   a. Rewrite this equation in Vertex Form by completing the square: __________________________ (Show ALL work below)

   b. Identify the vertex: __________

   c. Graph the arrow’s flight on the graph on page 3 (label the vertex and at least 2 other points on the graph).
To know if a Mario gets hit by the fireball, we need to know if it intersects within a certain radius of him. In programming, we would need to code in a circle around Mario and see if the fireball touches it.

3. We want Mario to get “hit” if the fireball is within 2 units of him. In other words, we want the radius to be 2.
   a. Write an equation using Mario’s position (part one, question one) as the center of our circle and with radius 2. ________________________________
   b. Graph the circle on the graph on page 3 (label graph using its equation, label at least 3 points on the graph).
   c. Did Mario get hit by the fireball? ________

4. What if the hit-radius for Mario is 3 units?
   a. Write an equation using Mario’s position (part one, question one) as the center of our circle and with radius 3. ________________________________
   b. Graph the circle on the graph on page 3 (label using its equation, label at least 3 points on the graph).
   c. Did Mario get hit by the fireball? ________
Reflection

This needs to be a separate page that is typed, proof-read for typos, spelling, and grammar. Use 12-point font and double space. Add a title (e.g. Math & Video Games). Provide a brief introduction explaining the lab in your own words. Also in the introduction, tell the audience which mathematical techniques you used in the lab (e.g. plotting points, graphs of quadratic functions, etc.). Then, please respond to each of the questions below. Your writing should be in an essay form (written in paragraphs) and at least one page in length.

Do you think this project shows how math can be applied to the real world? If “yes”, please elaborate-why are the results important or beneficial? If “no”, how could the lab change to make it more applicable to the “real world”?

Can you give an example of someone other than a video game writer that might be interested in this type of math? Be specific.

What other math do you think is used in video games? What about games that are not 2-dimensional, but 3-D and high definition?

Did this assignment change your opinion of the usefulness of math? Write one paragraph stating what ideas changed and why. If this project did not change the way you think, write how this project gave further evidence to support your existing opinion about applying math. Be specific.
Want More? Create Your Own Video Game
(extra credit)

Scratch is a program that allows people to “code” interactive stories, video games, and animations without all of the coding knowledge. One will still need to know strategies for problem solving and math skills.

1. Go to https://scratch.mit.edu/ (Firefox is not the best browser for this)
   a. Click Join Scratch and create account.
   b. Go to: https://scratch.mit.edu/projects/172584621/#player. Play the game to see how it works.
   c. Click “See inside” to see what tools were used to make the game.

2. From scratch homepage (https://scratch.mit.edu/) click Create. Create a short game that contains at least:
   a. One sprite (main character) that can move around the page.
   b. One “bad guy” that shoots some item(s) at the main character. The bad guy does not need to move but the more creative, the merrier.
   c. One out-of-bounds area for the character.

3. Get Creative!!!
   a. Put in sounds
   b. Decide what happens if the character get hits (example: did a wizard cast a spell that makes the main character grow in size?)
   c. Change the background
   d. Whatever you want!

4. When inside the editing page, record a video of the game.
   a. Click File and select Record & Export Video.
   b. Click Start and show all the different aspects of your game.
   c. Save and Download
   d. Email to me or upload to Canvas your recording and project page.
Using Math to Solve Crime

You are a detective for the Cambridge police. Last night, at approximately midnight, a burglar broke into a museum and stole many precious items. It is your job to look at the following information and solve the crime.

1. After looking at the security footage, you have the following information: A freeze frame shows the burglar measuring at 6cm and a statue measuring at 7cm. If the statue is actually 2.1 meters, what is the height of the burglar in meters? What is the burglar’s height in feet?

__________________________ meters  __________________________ feet

2. You find two different sets of prints at the crime scene. You don’t see an accomplice on the video footage, but you do get a distinct handprint (on next page). Given that a person’s hand span (length from tip of thumb to tip of pinky) to their height is a 1:10 ratio, what is the second burglar’s height?

_____ ft. _____ in.

3. The average criminal travels 70 miles per hour once on the freeway. From the museum, it takes at least a quarter of an hour to get to the freeway which is 5 miles away. If the burglars committed the crime ¾ hour ago, how far have they most likely traveled? (remember: \( d = r \cdot t \))

__________________________ miles

4. You send out a search radius using the above information. What is the perimeter of your search radius? How many square miles are you trying to cover? Use 3.14 for \( \pi \).

\( P = \) _______________________ miles  \( A = \) _______________________ square miles

5. The search for the criminals resulted in a high speed chase that ended with a crash. You have to determine how fast the burglars were traveling before impact. Given the distance of a skid mark, you can determine the velocity a car was traveling using the formula \( v = \sqrt{2 \cdot g \cdot d \cdot f} \) where \( v \) = velocity (ft/sec.), \( g \) = gravity (32.2 ft/sec.²), \( d \) = distance (ft.), and \( f \) = friction (0.75-known from testing similar car on similar surface). If the burglars’ car left a skid mark 252 feet long, find the speed of the car before impact. Then use dimensional analysis to convert this to miles per hour (mph).

\( V = \) ______________ ft/sec.  \( V = \) ______________ mph
6. On average, police solve no more than 13 crimes out of 100. What is the ratio of crimes solved to crimes unsolved? What percent of crimes are solved?
Information About This Station

The graph shown above shows the water level depth in a water well from 1940 through 2012. This particular well is located near the Orem Center Business Park, just west of UVU. The following information provides a more thorough description of the well (in case you are interested):

DESCRIPTION:
- Latitude 40°16'22.3", Longitude 111°43'32.1" NAD27
- Utah County, Utah, Hydrologic Unit 16020201
Well depth: 110 feet
Hole depth: 110 feet
Land surface altitude: 4,520 feet above NGVD29.
Well completed in "Valley Fill" (100VLFL) local aquifer


There are two y-axes in this graph. On the left you see the depth to water level in feet below the land surface. Notice that the numbers are in reverse from what you may be used to seeing. On the right you see the elevation above the National Geodetic Vertical Datum (NGVD).

**Part 1 Project Requirement**

1) **This part is worth 15 points, but work must be shown in order to achieve full credit.** This means: (a) showing steps in how you obtained the slope (10 points), and (b) showing steps leading up to the equation itself (5 points). I need to be able to follow your work and penmanship/organization must be clean. Find the equation of the trendline, WRITTEN USING FUNCTION NOTATION (the best-fit straight line passing through the graph shown above). Hint: Have “zero” represent the year 1938, and have 75 represent the year 2012. Also, I recommend using the elevation data on the right-side y-axis for the y-values, since the depth to water level is in reverse from what you are used to seeing.

2) **This part is worth 5 points, but work must be shown in order to achieve full credit.** This means inputting 83 into the equation and showing steps as to how you got to your answer. I need to be able to follow your work and penmanship/organization must be clean. Using the equation you just derived, find the water level elevation for the year 2020. (Hint: If 75 represented the year 2012, what will you use to represent the year 2020?) You must use this equation to determine this value. Only use an extrapolation of the graph to check the accuracy of your answer.

3) **This part is worth 5 points.** You must answer using a short paragraph with complete sentences. Since I’m asking you for a paragraph, I need to see at least three complete sentences. What does this graph mean? Do you think this graph is an accurate representation of water levels throughout Utah Valley? Why or why not?

This assignment must be turned in by the beginning of class on the date shown on the course calendar.
COURSE PROJECT – PART 2
Solving the AQI Formula for a Specific Variable
(Worth 30 points)

Computing the AQI
The air quality index is a piecewise linear function of the pollutant concentration. At the boundary between AQI categories, there is a discontinuous jump of one AQI unit. To convert from concentration to AQI this equation is used:

\[ I = \frac{I_{\text{high}} - I_{\text{low}}}{C_{\text{high}} - C_{\text{low}}} (C - C_{\text{low}}) + I_{\text{low}} \]

where:
- \( I \) = the (Air Quality) index,
- \( C \) = the pollutant concentration,
- \( C_{\text{low}} \) = the concentration breakpoint that is \( \leq C \),
- \( C_{\text{high}} \) = the concentration breakpoint that is \( \geq C \),
- \( I_{\text{low}} \) = the index breakpoint corresponding to \( C_{\text{low}} \),
- \( I_{\text{high}} \) = the index breakpoint corresponding to \( C_{\text{high}} \).

Part 2 Project Requirement
1) **This part is worth 25 points.** Solve the above-mentioned formula for \( C_{\text{low}} \). You must show your work by including the following steps: (a) Clearing out the fraction (5 points), (b) distributing where necessary (8 points), (c) gathering terms with \( C_{\text{low}} \) on one side of the equation and placing all other terms on the other side of the equation (8 points), (d) factoring out \( C_{\text{low}} \) on one side of the equation (3 points), (e) writing the correct answer (6 points). I need to be able to follow your steps. (Hint: To make this easier on yourself, I recommend using different variables to represent those with subscripts. For example, let \( w = C_{\text{low}}, x = C_{\text{high}}, y = I_{\text{low}}, \) and \( z = I_{\text{high}} \).) If I cannot follow your steps then no credit will be given for the entire assignment, so use good penmanship and keep things orderly!

2) **This part is worth 5 points, but work must be shown in order to achieve full credit.** This means showing: (a) the equation set up, with numbers properly substituted for variables (1 point), (b) simplification of the numerator (1 point), (c) simplification of the denominator (1 point), (d) the end result after division (2 points). Again, I need to be able to follow your steps and you must have good penmanship. Assuming the pollutant concentration is 51.0 micrograms per cubic meter, the high-end concentration breakpoint of 55.4.0 micrograms per cubic meter, the low-end index breakpoint of 101 micrograms per cubic meter, and the high-end index breakpoint of 150 micrograms per cubic meter, what would the low-end concentration breakpoint have to be in order to give an AQI of 139 micrograms per cubic meter? (Incidentally, the AQI for Orem, Utah on January 11, 2015 was 139 micrograms per cubic meter, which is categorized as “unhealthy for sensitive groups” by the EPA. Finding the low-end concentration breakpoint would help distinguish where the concentration breakpoint would have to be in order to upgrade to the “moderate” category of air quality.)

This assignment must be turned in by the beginning of class on the date shown on the course calendar. You may email it to me, if you wish.
Help for this project can be found through my environmental research specialist, xxxxxxxx. Her contact information is xxxxxxxxx. (Incidentally, she also works at the math lab in LA201, on Monday afternoons, I believe.) She helped me create a lot of what y’all are doing with the research project this semester. You can also work through my math mentor, xxxxxxxxxx. Her contact information is xxxxxxxxxx. She is also well versed in the project and can be of assistance to you.
MAT 1010 Course Project Part 3

The following chart shows the amount of municipal solid waste and the recycling rates for the USA between the years 1960 – 2012. (Source: www.epa.gov/sites/production/files/2015-09/documents/2012_msw_fs.pdf)

![Figure 2. MSW Recycling Rates, 1960 to 2012](image)

Your assignment: Find the exponential growth rate for the Total MSW Recycling curve (the one with the triangles). To do this, you will need the following formula:

\[ y = C(1 + r)^x \]

where

- \( C \) = the initial amount
- \( r \) = the growth rate
- \( x \) = number of time intervals

Part 3 of the course project will be worth 30 points. You must show your work for full credit. There are several ways to get this answer, but you need to show your work and I need to be able to follow it. Don’t forget to write the answer as a percentage!

You can also get help from the math mentor xxxxxxx and the math tutor/environmental consultant xxxxxxxxx. Their emails are: xxxxxxxxxxx and xxxxxxxxxxx. However, do not wait until the day before the assignment is due to ask them for help. They are also students and have busy schedules as well.