IMPACT Problem-Based Task

Title of Task: Redrawing Captain America's Shield **Cluster:**
Course: Math 1 **Unit: Algebra & Geometry**
Author: James O'Neal, Jr.

Task Overview: This task explores the real world concepts of modeling math in cinema. It also models the real world application of what employers may look for in potential candidates. Throughout the task students will learn how to successful recreate a star by using equations of lines and properties of those equations. This task explores mathematical concepts such as distance, equations of lines, systems of linear equations and their solutions, simplifying algebraic expressions, and the area of polygons.

Standards	Objectives
NC.M1.G-GPE.4 ***Use coordinates to prove simple geometric theorems algebraically.*** Use coordinates to solve geometric problems involving polygons algebraically • Use coordinates to compute perimeters of polygons and areas of triangles and rectangles. • Use coordinates to verify algebraically that a given set of points produces a particular type of triangle or quadrilateral.	Find the distance between two points using the distance formula.
NC.M1.A-APR.1 ***Perform arithmetic operations on polynomials.*** Build an understanding that operations with polynomials are comparable to operations with integers by adding and subtracting quadratic expressions and by adding, subtracting, and multiplying linear expressions.	Simplify a polynomial expression.
NC.M1.A-REI.10 ***Represent and solve equations and inequalities graphically*** Understand that the graph of a two-variable equation represents the set of all solutions to the equation.	Write a system of equations and solve for the solutions.

Additional/Prerequisite Skills:

• Graphing lines (8.EE.5, 8.EE.6, 8.F.3)
• Analyze and solve pairs of simultaneous linear equations by graphing and substitution (8.EE.8)
• Understanding functions
• Add, subtract, factor and expand linear expressions (7.EE.1)
• Understand that rewriting expressions into equivalent forms can reveal other relationships between quantities (7.EE.2)
• Finding the distance between points in the coordinate plane (8.G.8)

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Emphasized Standards for Mathematical Practices:

3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
6. Attend to precision.
7. Look for and make use of structure.

Making Connections (Hook, Multi-media link, Visual Aid, etc.):
Captain America's Fights: https://www.youtube.com/watch?v=QP8l6J_H38g
Picture of the shield:
https://vignette2.wikia.nocookie.net/marvelcinematicuniverse/images/3/36/Captain_America_Shield.png/revision/latest?cb=20160324205933

Suggested Pacing Calendar (within the unit):

Day 1: Intro of Video & Task 1	Day 2: Task 2 through 3

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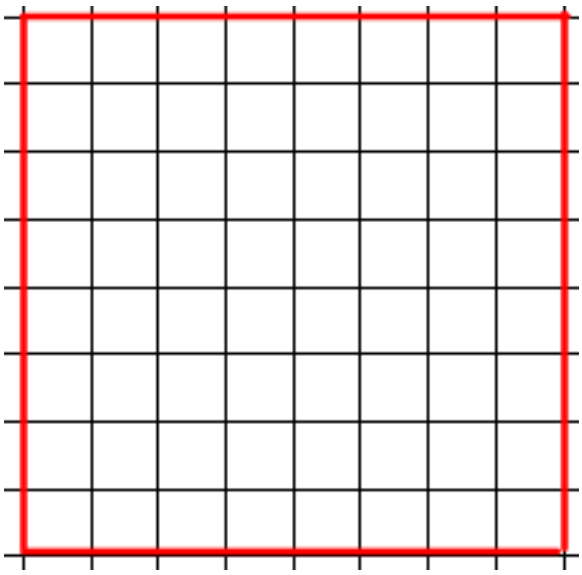
Task: Your dream job is to work at Marvel Studios as a graphic artist. One of the tasks that Marvel puts before all their designers is to recreate the star inside of Captain America's shield. Many of the graphic artists struggle in seeing the math within the art. They don't understand the symmetry and that many of their art is made up of lines that form images. Though computers are a wonderful tool, Marvel realizes that there are some foundational mathematics that are true to the core of who they are as a company.

TASK 1: You are given the following square and the following instructions to form the star. Extend all the lines until so they fit in the box:

1. **The origin is at the center of the square.**
2. **The right side of the star has a y-intercept of four and a slope negative 3.**
3. **The left side of the star has the opposite slope of the right side.**
4. **The horizontal bar is one unit above the origin.**
5. **The intersection of east point of the star forms a line with a slope of 2/3.**



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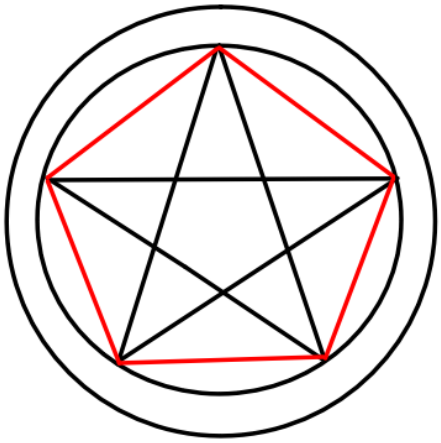
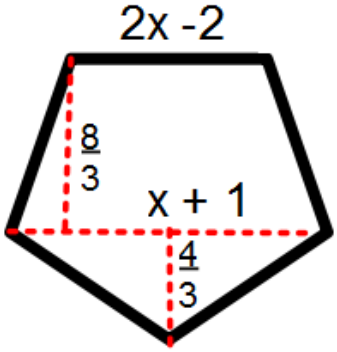
TASK 2: Then you are asked to find the coordinates of all points of the star.

TASK 3: Next Mr. Latrell, the director, says that you could've built this star by drawing a regular pentagon and connecting your points to form the star. Your job is to prove that he is correct or show why his mathematical theory may be off. Use the star that you built in task 1. What is the perimeter of your pentagon? Round your answers to the nearest hundredth place if necessary.



TASK 4: It's almost over! Mr. Latrell says that the middle of the star forms a hexagon. He gives you the following problem and asks you to find the area of the hexagon. He says the only thing he will give you is the area formula of a trapezoid: ½ h (a + b) where a & b are the top and bottom lengths of the trapezoids.



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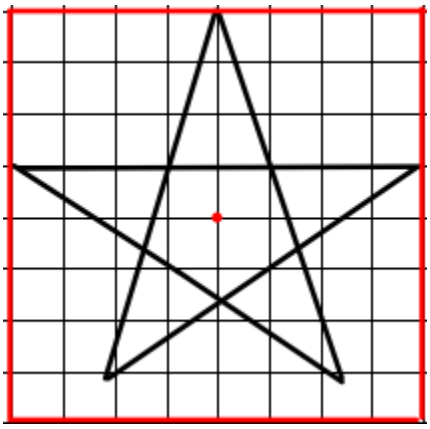
Solutions:

Task 1:



Task 2:

Solutions to the system: (0,4), (4,1), (17/7, -23/7), (-17/7, -23/7), (-4,1)

Students will have to use substitution to solve for at least one of the points in the bottom. The equations are y = -3x + 4 and they have to use a point on the line going diagonal from the left corner "point" to find the intersection of the two segments in the bottom right "point". I chose (-1,1) but students can choose (-4,1) or even (2,3) once they substitute they get the equation to be y = -2/3x – 5/3. Now they can use substitution or elimination to solve for the ordered pairs. Most students will use substitution:

-2/3x – 5/3 = -3x + 4 <= Multiply all by 3 **y = -3 (17/7) + 4**

-2x – 5 = -9x + 12 ← Add 9x and 5 to both sides **y = -51/7 + 4**

7x = 17 divide by 7 **y = -23/7**

x = 17/7

Solution (17/7, -23/7) I would encourage students to leave as fractions.

Students should notice symmetry and the other bottom point is the opposite x and the same y so the point would be (-17/7, -23/7).

Task 3: Students will need to use the distance formula for east point and southeast point and the west point and south west point. An example would be for the points (4,1) and (17/7, -23/7) the equation would look like $\sqrt{\left(\left(4-\frac{17}{7}\right)^2+\left(1+\frac{23}{7}\right)^2\right)}$ **= which would be 6.76. The distance around starting from Top counterclockwise is: 5 units, 4.56 units, 4.86 units, 4.56 units, and 5 units. The perimeter would be approximately 28.38 units.**

Task 4:

Trapezoid: ½ h (a + b)	**Triangle: bh/2**	**Combined: ½ h (a + b) + bh/2**
½(8/3)[(2x – 2) + (x + 1)]	**½ (4/3) (x + 1)**	**(4x – 4/3) + (2/3x + 2/3)**
8/6(3x – 1)	**4/6(x + 1)**	**14/3x – 2/3**
4/3(3x – 1)	**2/3(x + 1)**	
4x – 4/3	**2/3x + 2/3**	

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Scaffolding:

Task 1

- **What do we know about negative slopes?**
- **What does the word opposite mean? It didn't say opposite reciprocal which would imply what…perpendicular?**
- **What does 2/3 mean. What happens if I can't go up how can we keep the relationship a positive slope?**
- **If you're missing the other side what does symmetry imply?**

Task 2

There are three points that are simple to find the other two takes some work.

- **What does the solution to a system mean?**
- **Since the bottom two points of the star are not on an integer what do you need from the lines to solve this algebraically?**
- **If I'm given a point and a slope how can I write the equation of the line?**
- **What method would you use if you have both y's alone?**
- **Since the star is symmetric to the other side how can find the other bottom point?**

Task 3

- **What does a regular polygon mean? What is Mr. Latrell implying about the sides of his pentagon?**
- **How can we find the length of each side without measuring?**
- **Leave your answers as a fraction.**

Task 4

- **How do you find the area of the entire trapezoid?**
- **If you can't remember the area of a triangle draw a square and manipulate it.**

Instructional Strategies:

- Before introducing the task, I would definitely show the video to get the kids hooked. A lot of your students will be marvel fans so this would definitely keep them engaged.
- It may be beneficial to review writing equations given the point and the slope.
- It will also be beneficial for students to understand that the solution to a system is where the two lines meet and they don't have to meet at an integer.
- I would stress to the kids this is an exact science and that they should not be estimated anything until they are asked to round.
- I would also go over concepts of symmetry just that students understand that it doesn't mean that everything is the same. Students should be familiar with reflections from 8^{th} grade but may need a refresher.

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- Your lower students will be dealing with fractions and so just assure them that a fraction is a number. I know at times funny looking fractions like 17/7 doesn't make sense to them but reassure them that as long as the process is correct, their fractions will be fine.
- I would encourage both lower and higher students to use a calculator. If the calculator does not put a double parenthesis around the number they will get the wrong answer. **STRESS** TO THEM the importance of this. i.e. $\sqrt{\left(\left(4-\frac{17}{7}\right)^2+\left(1+\frac{23}{7}\right)^2\right)}$.
- Lastly encourage your students to leave their numbers as a fraction but check the graph to see if their numbers make sense as a decimal. They should be able to reason through to see that they cannot fit any point greater than the absolute value of 4 on any axis.