My favorite Coal Mine

Overarching Goal of Unit: To research effects of mining on the environment-both positive and negative-and to prepare argumentative writing pieces using their research as evidence. **(Note that this Unit is focused on one coal issue.)**

The Over-Arching Goal of Unit Goes Here >: Students will investigate how one piece of property in Eastern Ky can be utilized to help ensure the present and future prosperity of the local community

Essential Questions: (1-3) These should be thinking questions that generally begin with "How" or "Why" and may have multiple answers.	KCAS Standards (list those that will support each essential question and will be assessed in the unit.)	I Can Statements of what students will be able to do	Assessments/Products (list at least one assessment or product for each standard.) Formative Assessment Is on-going as teacher checks students' progress. Summative Assessment will be the final product.	Activities (describe activities that support the assessment(s)/ product(s) and advance the standard.)	List materials required for each activity.	Cost
1. How can a model mine be utilized to help us understand the value to our community of a piece of previously mined property located in Eastern Kentucky?	**G-GMD Explain volume formulas and use them to solve problems** 1. Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. Use dissection arguments, Cavalieri's principle, and informal limit arguments. 3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve	1a. I can use volume formulas to accurately estimate the volume of coal in the coal seam and use the estimated volume to determine its current market value.	1a. Students will make a numerical picture of the coal seam and use it to produce a 2-D picture of the coal seam on graph paper.	1a. Students will work with a partner to use the 2-D picture of the coal seam and the polygonal method to determine the volume and value of the coal located on the property.		

1

03-05-19

	problems **A-CED** **Create equations that describe numbers or relationships** 1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions. 2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. 3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For example, represent inequalities describing nutritional and cost constraints	1b. I can use systems of equations and weighted linear combinations to make inferences based on statistical data to predict the height of our coal seam at the deepest part of a coal slurry pond that is located on the property.	1b. Students will produce a 2 – 5 page report and a tri-fold presentation board to describe the mathematical techniques used to predict the height of the coal seam at the coal slurry pond.	1b. We will have a guest engineer teach students about underground coal mine preplanning and design. He will also discuss the importance of adequate roof control and ventilation. 1b. Students will work in groups of 4 to design, solve, and explain one problem involving the estimation of the height of the coal seam at a coal slurry pond located on the property and use the projected height and the polygonal method to determine the volume and value of the coal located on the property.	2 [illegible]ries for TI-84 Calculators $90 3-ring binders $30

	on combinations of different foods. **Understand and evaluate random processes underlying statistical experiments** 1 Understand statistics as a process for making inferences about population parameters based on a random sample from that population. 2 Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. For example, a model says a spinning coin falls heads up with probability 0.5. Would *a result of 5 tails in a row cause you to question the model?* N-VM 5 (+) Multiply a vector by a scalar. a. Represent scalar multiplication graphically by scaling vectors and possibly reversing their direction; perform scalar multiplication component-wise,	1c. I can use the volume formula for a cylinder, area formula for a circle, and perform scalar multiplication to determine if a coal slurry pond can safely be located	1c. Students will present their problem and their solution on a 3-sided presentation board.	1c. Students will work with a partner to determine if the coal slurry pond can safely be located over top of our model underground coal mine. The team will use vector mechanics to analyze the	fold boards $300

	e.g., as c(v x, v y) = (cv x, cv y). b. Compute the magnitude of a scalar multiple cv using ||cv|| = |c|v. Compute the direction of cv knowing that when |c|v ≠ 0, the direction of cv is either along v (for c > 0) or against v (for c < 0). **G-GMD** **Explain volume formulas and use them to solve problems** 1. Give an informal argument for the formulas for the circumference of a circle, area of a circle, volume of a cylinder, pyramid, and cone. Use dissection arguments, Cavalieri's principle, and informal limit arguments.	on the property without causing a catastrophic collapse of the underlying rock strata into the mine.		stability of the underlying rock strata and determine the minimum safe distance that the mine must be from the bottom of the slurry pond.	
	Visualize relationships between two-dimensional and three-dimensional objects 4. Identify the shapes of two-dimensional	2a. I can use relationships between 2-D and 3-D objects and use geometric shapes, their	2a. Students will produce a model underground coal mine.	2a. Students will work as a large group to design and build a "model" underground coal mine in our school. This mine	Wood furring strips.....$105 Wood Screws............$36 Black Roofing felt.........$52 Duct tape...................$16

5

	cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects. **Modeling with Geometry G-MG Apply geometric concepts in modeling situations** 1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).★ 2. Apply concepts of density based on area and volume in modeling situations (e.g., persons per square mile, BTUs per cubic foot).★ 3. Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios)	measures, and their properties to design and build a model or “mock” underground coal mine to scale.		will be a scaled down version of an actual mine. It will have at least one entry and one break and it will be large enough so that students can actually crawl back into the mine.	

	1.16 Students use computers and other kinds of technology to collect, organize, and communicate information and ideas 5.1 Students use critical thinking skills such as analyzing, prioritizing, categorizing, evaluating, and comparing to solve a variety of problems in real-life situations.	2b. I can apply the relationships between 2-D and 3-D modeling to use the Surfer 8 computer software to estimate the volume of coal in the coal mine, estimate the height of the coal beneath the coal slurry pond, and produce 2-D and 3-D pictures of the mine.	2b. Students will produce accurate printouts of the 2-D and 3-D pictures of the mine, and accurate printouts of the computer estimates of the volume of coal in the mine and the height of the coal seam at a point beneath the slurry pond.	2b. Students will work in groups of 3 – 4 to use the Surfer 8 computer software to calculate the volume of coal in the coal seam, estimate the height of the coal seam at a point beneath the slurry pond, and generate the 2-D and 3-D pictures of the coal seam.	
	1.16 Students use computers and other kinds of technology to collect, organize, and communicate information and ideas 5.1 Students use critical thinking skills such as analyzing, prioritizing, categorizing, evaluating, and comparing to solve a variety of problems in real-life situations	2c. I can use robotics technology to help ensure the safety of our underground coal miners.	2d. Students will produce video and/or pictures of a robot locating a roof fall in our underground coal mine.	2d. Students will work as a whole group to set up a simulated roof fall in our "model" underground coal mine. They will send a robot into the mine and use the live video feed to locate the roof fall and determine if there are any casualties. A simulated rescue mission will be conducted to retrieve any injured miners. Our school Robotics Team and our guest	…otics kit…………….$50

				engineer will assist with this simulation.	
	G-GPE Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula **G-GMD** 3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems **G-MG** Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints or minimize cost; working with typographic grid systems based on ratios) **A-CED** 3 Represent constraints by equations or inequalities, and by systems of equations and/or inequalities, and interpret solutions as viable or nonviable options in a modeling context. For	3a. I can apply geometric methods and volume formulas to estimate the maximum pillar size at our mine if the mine incorporates square pillars and maximum recovery is desired (50%). 3b. I can use constraints by inequalities to determine the minimum laboratory compressive strength of the coal at the mine and determine the	3a. Students will reproduce a 1-3 page report with one correctly solved problem involving maximum pillar size. 3b. Students will produce a 1-3 page paper documenting how they correctly found the strength of the coal at our mine and determined the safety factor using the Holland-Gaddy relationship.	3a. Teacher will conduct a large group discussion concerning the importance of roof control in an underground coal mine and demonstrate how to estimate maximum pillar size in our underground coal mine. 3b. Students will work in small groups to design and solve at least one strata control problem involving maximum pillar size and laboratory compressive strength, and determine the	8 9

	example, represent inequalities describing nutritional and cost constraints on combinations of different foods. 4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. For example, rearrange Ohm's law V = IR to highlight resistance R.	safety factor for compressive failure of the mine pillars by utilizing the Holland-Gaddy relationship		safety factor of our model mine. Students must show all calculations and data and the problem should be applicable to our mine	
	A-CED Create equations that describe numbers or relationships 1 Create equations and inequalities in one variable and use them to solve problems. Include equations arising from linear and quadratic functions, and simple rational and exponential functions.	3d. I can create and use equations in one variable and use the area formula of a circle to calculate the diameter of the roof bolts needed to provide adequate roof support.	3d. Students will produce a one page report showing their best recommendation for the diameter of the roof bolts used at our coal mine.	3d. Students will work in groups of 2-4 to design and solve at least one problem that will determine the diameter of the roof bolts that we will use at our model mine.	
	G-GMD Explain volume formulas and use them to solve problems 1. Give an informal argument for the formulas for the circumference of a circle, area of a circle,	4a. I can use volume formulas, 2-D and 3-D relationships, and apply geometric modeling to calculate the distribution of air	4a. Students will present their problem and results on a 3 sided presentation board demonstrating the correct air distribution among 2-4 parallel splits and	4a. Our guest engineer will discuss the importance of proper underground coal mine ventilation. 4a. Students will be placed in groups of	Tri-fold presentation Boards

	volume of a cylinder, pyramid, and cone. Use dissection arguments, Cavalieri's principle, and informal limit arguments. 3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems. **Visualize relationships between two-dimensional and three-dimensional objects** 4. Identify the shapes of two-dimensional cross-sections of three-dimensional objects, and identify three-dimensional objects generated by rotations of two-dimensional objects. **Modeling with Geometry** **G-MG** **Apply geometric concepts in modeling situations** 1. Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).	according to natural splitting among 2-4 parallel splits and determine the impact of pressure change on the ventilation system of an underground coal mine .	the impact of pressure change on our ventilation system.	3 – 4 and asked to design the ventilation schematic for the mine needed to calculate natural air splitting. They will also determine the impact of pressure change on the on the ventilation system of our underground coal mine.	

	HS-PS3-1.Create a Computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	5a. I can use the change in energy of one or more components to analyze the ash, moisture, BTU, and sulfur content of the coal that is mined at the underground coal mine.	5a. Students will generate a 1-3 page lab report of their and analysis and will present their data and results on a 3-sided presentation board.	5a. Students will be placed in groups of 4 lab partners and assigned the take of determining the ash, moisture, sulfur, and BTU content of the coal at our underground mine.	13 …d presentation Boards
	. 2.19 • human actions modify the physical environment and, in turn, the physical environment limits or promotes human activities	6a. I can research how human actions impact the history of underground coal mining in Eastern Kentucky	6a. Students will present their research in a 3-ring binder and will present their research on a tri-fold presentation board.	6a Students will go to the library and work with a partner to research a specific topic concerning the history of coal mining in Kentucky and describe how their topic has impacted the communities in ou… area.	14 …old presentation Boards
	2.30 Students evaluate consumer products and services and make effective consumer decisions.	7a. I can bake a cake or pastry that models the coal seam and the surrounding rock strata.	7a. Students will produce a 3-D model of the coal seam using vanilla and chocolate pudding or light and dark cake.	7a. Students will work in groups of 2-4 to bake a cake or pastry that illustrates the coal seam and its surrounding strata.	15
	1.14 Students make sense of ideas and communicate ideas with music. • create new, listen to,	8a. I can communicate my ideas with music by playing and\or composing the music lyrics of a	8a. Students will produce a CD or DVD of their song	8a. Students will work independently or with a small group to write and perform a song about coal mining.	16

	choose and perform music to fulfill a variety of specific purposes **2.22** Students create works of art and make presentations to convey a point of view. • create new, choose and experience artworks created to fulfill a variety of specific purposes	song that has coal as a central theme. 8b. I can construct a 2-dimensional or 3-dimensional work of art that is about underground coal mining.	8b. Students will produce and display a 2-D or 3-D work of art.	8b. Students will work independently or with a small group to create a 2-D or 3-D work about underground coal mining.	17 picture Mats/ king..................$30
	FLE Construct and compare linear, quadratic, and exponential models and solve problems 1 Distinguish between situations that can be modeled with linear functions and with exponential functions.	9a. I can use exponential models to estimate the number of transplanted hardwood trees that are still growing on the property at the end of a specified period of time.	9a. Students will produce a rubric to evaluate the work of at least one other group and will present their data and results on a 3-sided presentation board.	9a Students will work with 2-3 other students to design and solve at least one problem involving statistical estimation of transplanted or seeded trees on reclaimed surface mine property. They will develop a rubric that the teacher or other students can use to grade their problem.	18 Tri-fold presentation Boards

	FLE Construct and compare linear, quadratic, and exponential models and solve problems 1 Distinguish between situations that can be modeled with linear functions and with exponential functions	9b. I can use exponential modeling to estimate the 5^{th} year growth rate of an elk population that that was transplanted to the property after all surface mining was completed.	9b. Students will present their data and results on a 3-sided presentation board.	9b. Class will conduct a large gr discussion concerning the use of exponentials and logarithms in estimating transplanted animal populations.	i-fold presentation Boards
	FLE Construct and compare linear, quadratic, and exponential models and solve problems	9c. I can use logarithmic modeling to estimate the number of years until the transplanted elk herd has reached its maximum carrying capacity.	9c. Students will present their data and results on a 3-sided presentation board.	9a Students will work with 2-3 other students to design and solve at least one problem modeling when the transplanted elk herd has reached maximum carrying capacity on the reclaimed surface mine property. They will develop a rubric that the teacher or other students can use to grade their problem.	fold presentation ards
	2.18 Students understand economic principles	10a How can I use economic principles to	10a. Students will produce a business plan that can be used	10a. Students will arrange mine tours of our scaled "model"	

	and are able to make economic decisions that have consequences in daily living.	develop a product or service that can be used to financially assist our school community.	to generate a profit from our "model" underground coal mine.	mine. Any person within our school community can purchase a ticket and, for a nominal fee, can tour our mine. Any funds generated by our mine tours will be donated to a selected group or team at our school.		
			10a. Our visual arts students will produce works of 3-D coal art.	10a. Our visual art students use small pieces of the coal that has been removed from our mine to produce works of 3-D coal art. These works of 3-D art will be sold in a silent auction and the proceeds will be used to beautify our school campus.	Pieces of coal	$00
	Writing Standards 10-12 3.) Write narratives to develop real or imagined experiences or events using effective techniques, well chosen details, and well structured event sequences.	11a. I can write a poem, short story, or essay about coal mining. This means I can give clear reasons and relevant evidence to support my essay or story.	11a. Students will produce a 2 – 4 page essay, poem, or short story with coal mining as the central theme.	11a. Students in a senior English class will go a computer lab and work independently to write an essay, poem, or short story with coal mining as the central theme.		

Student Initiated Activities

These are two activities that our students wanted to add to our unit. They are not in the original plan that we submitted in the fall. We consider our coal study unit to be student driven and we encourage our students to add activities to the unit as it is progressing. The two additional activities are #24 and #25. They will be indicated with a red dot.

Activity #24:
Have each student spend some time in the mine. This will show each student what it would be like to go into a real coal mine.

Activity #25;
It might be fun to "hang out" in our model mine. It's like a 4 foot high tent.

The Introduction

My Favorite Coal Mine

I. The INTRODUCTION

We did it! We built an underground coal mine at our school. Our "model" coal mine has two entries and one break. It also has a mine fan to provide ventilation. This model coal mine became the centerpiece around which our Coal Study Unit revolved. It all started when I asked the students in my Advanced Topics class to list at least three activities or ideas that they would like to see included in our unit. Predictably, I received some silly responses: pizza party, nap time, etc., but I also received several excellent ideas. One student wrote about how fun it would be to build our own underground coal mine at our school. When I read this student's recommendation, I initially believed that this could not be done. Finding a location for the model mine at our school, the logistics of getting materials, and inexperienced students working with power tools were very real concerns. However, by coordinating with our principal, the school finance officer, and the other teachers participating in the unit, our students overcame all obstacles and they did it--they built our Model Coal Mine.

So…now we have an underground coal mine in our school building. What do we do with it? We decided to use our model underground coal mine to help teach the students at our school to understand the important role of coal and coal mining in the development of our region's economy. This would include the history of coal mining, problems facing today's mining industry, and what the future holds for the coal mining industry in our area. Our model mine took centerstage when we wrote our essential question for our Coal Study Unit:

**How can a model mine be utilized to help us to understand
the value to our community of a piece of previously
mined property that is located in Eastern Kentucky?**

Our model mine helped us to teach our students about the history of coal mining, the obstacles facing today's surface and underground mines, and how a piece of property can be utilized by the community long after the mine is gone. In reality, our "model" coal mine made our Coal Study Unit ***relevant*** and ***real*** to our students. Students were no longer writing and solving a problem about mine ventilation; they were ventilating the mine that they helped to build. When a group of math students calculated the diameter of the roof bolts for their mine, they could walk down the hallway and see and touch the mine. As a high school math teacher, it is always difficult to get my students to understand how and why mathematics and science is important and relevant to them and relevant to their futures. Our model mine helped my students to better understand this relevance to coal mining and to their daily lives. Our one essential question was broad enough to include all academic departments at our school, it allowed for the participation of as many students as possible, and the unit emphasized contextual learning and project-based learning whenever possible. Students who are engaged in hands-on learning activities are much more likely to retain what they have learned. Our unit challenged students to solve real-world problems encountered in coal mining. They had to think critically, they used problem-solving skills, and they were engaged at the highest levels of Bloom's Taxonomy. The unit also addressed the core content standards in each academic area and satisfied specific elements within the Program of Studies for each course.

I was driving down the road one day…

Just recently, one of my students told me about how he was driving to a friend's house on a 2-lane road and he got stuck behind a slow-moving coal truck. He told about how he started to get mad, but then he realized that this was the first time since he had gotten his license that he had been caught behind a coal truck while driving in our county. He said that this may be a good omen for the coal industry. I want to believe that maybe my student is correct and that the coal industry will begin to pick up soon. I want to believe that we can be optimistic and hope that the good mining jobs will stop leaving this county. I want to believe that there will be no more empty seats in my classroom because my students had to transfer to another school outside the area when one of their parents lost their coal mining job. I want to believe…

The tales they tell…

Every year I involve my students in the development of our Coal Study Unit. I ask my students to recommend activities and projects that they would like to participate in as part of our unit. They always have some great ideas. We then discuss which activity to include or exclude from our unit and we talk about coal mining in general. One of the topics that we discussed was the decline of the coal industry in our area. I was surprised that so many of my students indicated that they knew of a family member or a family member of one of their friends that had lost their mining job and had to leave the area. We also talked about how dangerous coal mining can be. Several students told about parents or family members who had developed back problems after working in the mines and how difficult it has been for them to get disability so they could continue to support their families. One of my Advanced Topics students told our class how her uncle's legs had been crushed in a rock fall while working underground. Sadly, he had to have both legs amputated below the knees. After hearing of my students' concerns about mine safety, we decided that mine safety would be a point of emphasis in as many activities as possible in our unit. We concluded that the most important lesson that our students can learn from this year's coal study unit is that coal mining is a difficult and dangerous job and that the mining industry is doing everything possible to ensure that coal miners are not injured or killed as they perform their jobs.

How can we best use the land and coal resources of a piece of property in our area?

Try to come up with least 2 ideas that we can use with a piece of property that has coal on it. All ideas are welcome.

1.____

2.____

3.____

4.____

5.____

This is a copy of the form I use in planning our unit. Our students can make recommendations about activities that they would like to participate in. They always have some great ideas.

Activities and Goals

My favorite Coal Mine

Overarching Goal;

Students will investigate how one piece of property in Eastern Kentucky can be utilized to help ensure the present and future prosperity of the local community

Essential Question;

How can a model mine be utilized to help us understand the value to our community of a piece of previously mined property located in Eastern Kentucky

II. ACTIVITIES AND GOALS

The students who participated in this unit were kinesthetic learners. They designed and built a model underground coal mine in a classroom at our school using hammers, drills, screws, and furring strips. They worked cooperatively with other students and used their peer teaching skills to help their fellow students acquire new skills. They used critical thinking and problem solving skills to make decisions concerning design and operation of our model underground coal mine while applying and transferring previously learned skills to solve real life problems faced in today's underground mines. This coal study unit was an interdisciplinary integration project involving all academic departments at the school. It was integrated horizontally across all subject areas in such a way that the students participated and became part of a total immersion learning activity.

The Army came to our rescue...

One of the most anticipated activities of our unit involved the use of robotics technology to help ensure the safety of the miners as they removed the coal from our model mine. We wanted to stage a simulated roof fall in our mine and use a robot to enter the mine, locate the roof fall, and determine whether or not any coal miners were injured. A group of students would then launch a rescue mission into the mine to perform first aid and extract any casualties. The plan was for the robotics team at our school to provide the robot and the team would operate it as it searched for the roof fall. Sadly, the robotics team was unable to assist us. They were using their robot to prepare for an upcoming competition, and it could not be disassembled and moved to help with our mine rescue. Luckily, I have several math students that also participate in the Army JROTC program at our school and they informed me that the JROTC department has a robot. The Army JROTC provided us with full use of their robot. They allowed some of their students to help build the mine and operate the robot as it went into the mine and searched for the roof fall. They also allowed us to build our model underground mine and perform the simulation in one of their JROTC classrooms. The unanticipated help that we received from the Army JROTC was critical to the success of our coal study unit. A special thanks goes out to the Army JROTC instructors and students at our school for assisting with this activity.

The award for the most fun activity goes to…

Our students loved building our model underground coal mine. This activity allowed our students to use their creative abilities and problem-solving skills as well as work together as a team to accomplish a difficult task. The construction team consisted of approximately 10 students from my Advanced Topics class and several volunteers from the JROTC classes. They worked together to actually construct our model mine. The construction of the mine took about 4 hours to complete. It was 4 feet high; this would be considered normal height for an underground coal mine. Our mine had two entries that were 4 feet wide and 8 feet long. It had one break that was 12 feet long. This would be approximately 1/5 the size of a real underground coal mine. We had originally planned to use black roofing felt to cover the outside of our mine, but after one of my students indicated that roofing felt could be sticky and messy, we decided to use black artisan paper instead. After our mine was built, we were all amazed at how much our completed underground model mine looked like a real mine. It even had a fan that pulled air through the mine. Our model underground coal mine became an inspiration to our students and teachers as they participated in the different activities of our coal study unit.

The students in each content area were assigned to groups of 2 to 4 students and asked to investigate at least one specific element involving the utilization of the coal and land resources of the property on which our model mine was located. This could involve mining the coal using underground mining methods, removing the coal near the surface, or post land uses of the property. The following is a description of the activities in which students from the different departments at our school participated:

- Math students were placed in groups of 3 or 4 and used core-drilling data to get a numerical picture of any coal seams located on the property. They then used the polygonal method to determine the amount and value of the coal from any of these coal seams. They also placed a small pond on the property and used the surrounding core drilling data to predict the height of the coal at that location, using geostatistical techniques. Methods that were employed to predict the height of coal were inverse distance to a power, triangulation, and Delauney Triangulation. They also calculated the volume of the coal and predicted the coal seam height at a coal slurry pond located on the property using the Surfer 8 Simulation software. It was amazing how close the students' approximation of the volume of coal at the mine was to the approximation of the volume of coal using Surfer 8 Simulation software. Each group used the quadratic formula to calculate the minimum size of the remaining coal pillars and determine the minimum size roof bolt needed to safely support the roof given the seam height and depth of the mine. They determined the compressive strength of the coal at the mine and used this to determine the safety factor for failure of the mine pillars.

Our math students also designed a ventilation schematic of the underground mine located on the property. They calculated the distribution of air by natural splitting along 4 parallel splits and determined the air horse-power along each entry.

- Chemistry students performed coal analysis on the coal found at our mine site. This included tests for ash content, moisture, BTU, and calorific values.
- Students enrolled in our pre-engineering curriculum worked within their group to use the Surfer 8 contouring and 3-D mapping software to estimate the volume of coal on the property. They used the kriging and inverse distance to a square function of the Surfer 8 software to draw 2-dimensional and 3-dimensional maps of any coal seams. They used the Surfer 8 software to assist in the design of the underground coalmine on the property. They used mathematics to predict the height of the coal seam at the location of the pond that was located on the property.

These students used vector mechanics to determine whether a coal slurry pond could be safely placed over top of the active mine workings of our underground model mine. They calculated the vertical stress due to the overburden and horizontal stress due to the pressure from the coal slurry impoundment on the outcrop barrier pillar. They also determined the resultant force on an outcrop barrier pillar due to the force of the overburden and the coal slurry. They determined that due to the shear stresses at the outcrop barrier pillar it would not be safe to place a slurry pond close to or overtop of our model mine.

- I conducted a large group discussion with my Precalculus classes that involved the use of exponentials and logarithms in predicting transplanted animal populations. These students also investigated how to best utilize the property after any surface mining is completed. They were placed in groups of 2 – 4 and asked to design and solve at least one problem that estimated the number of trees on the property after reseeding the property to restore the original hardwood forest. They also designed and solved at least one problem that modeled the maximum carrying capacity to establish a viable elk population on the property by transplanting elk from an established herd. They used exponential functions to determine the growth rate of the herd after 5 years and the number of years until the elk herd would reach its maximum carrying capacity.
- Students in our English classes expressed how they felt about coal mining by writing either a short story or poem about coal mining.
- Students from our history classes went to the library and worked with a partner to research a topic concerning the history of coal mining in our area. They also described how their topic impacted the local community. These students presented their research in a 3-ring binder and on a tri-fold board.
- Technology was used in every academic area as a powerful tool to solve complex problems and make important decisions concerning the utilization of our piece of property and our model mine. The most impressive application of technology in this unit was the use of the robot in locating the roof fall in our model mine. Utilizing this technology meant that no coal miners were put in danger of injury or death. Another impressive application of technology was the use of the Surfer 8 Simulation Software in estimating the volume of coal located in our coal seam. All uses of technology in our unit were both challenging and relevant to the problems faced in underground coal mining.

- Art students produced 2-dimensional and 3-dimensional works of art with coal as the central theme. These students also painted and decorated pieces (lumps) of coal that was "mined" from our "model" underground coal mine. These pieces of coal art will eventually be sold at a silent auction at our annual Gala for the Arts, with the proceeds donated to our school's arts programs.
- Some of our music students worked with as group and composed and recorded songs about various aspects of coal mining and its impact on the people of Eastern Kentucky.
- Students in the culinary skills classes made a 3 layered dessert made of pudding. The pudding had bottom and top layers composed of vanilla pudding with a chocolate layer in the middle. This desert illustrated a 3-dimenaional cut-away view of the coal seam and the surrounding rock strata. They then had lots of fun eating this desert.
- How could we use our model mine to make money? As mentioned before, our students showed their entrepreneurial abilities by painting some of the pieces of coal that was removed from our mine. These decorated pieces of coal will be sold during a silent auction at the Gala for the Arts to raise money for our arts department. A second money making idea involved charging a small fee to "tour" our model mine. This was not very successful. After only one day we stopped charging admission and let everyone tour the mine for free. We were not disappointed that we did not make a lot of money with mine tours. We were proud of our model mine and we wanted everyone to see it.

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Activity #1

How much coal is located on our property? This was an activity where students worked with a partner to generate a 2-deminsional diagram of the coal seam and use the Polygonal Method to determine to estimate the volume of coal in our coal seam. This group determined that we have 13,088,000 tons of coal on our property

Activity #2 & Activity #11

Our guest engineer is an JROTC instructor at our school .He has an engineering background from when he served in the Army. He discussed with our construction crew the importance of adequate roof support and ventilation. He showed the students how the air is directed to the mine face where the miners are located

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03-05-19

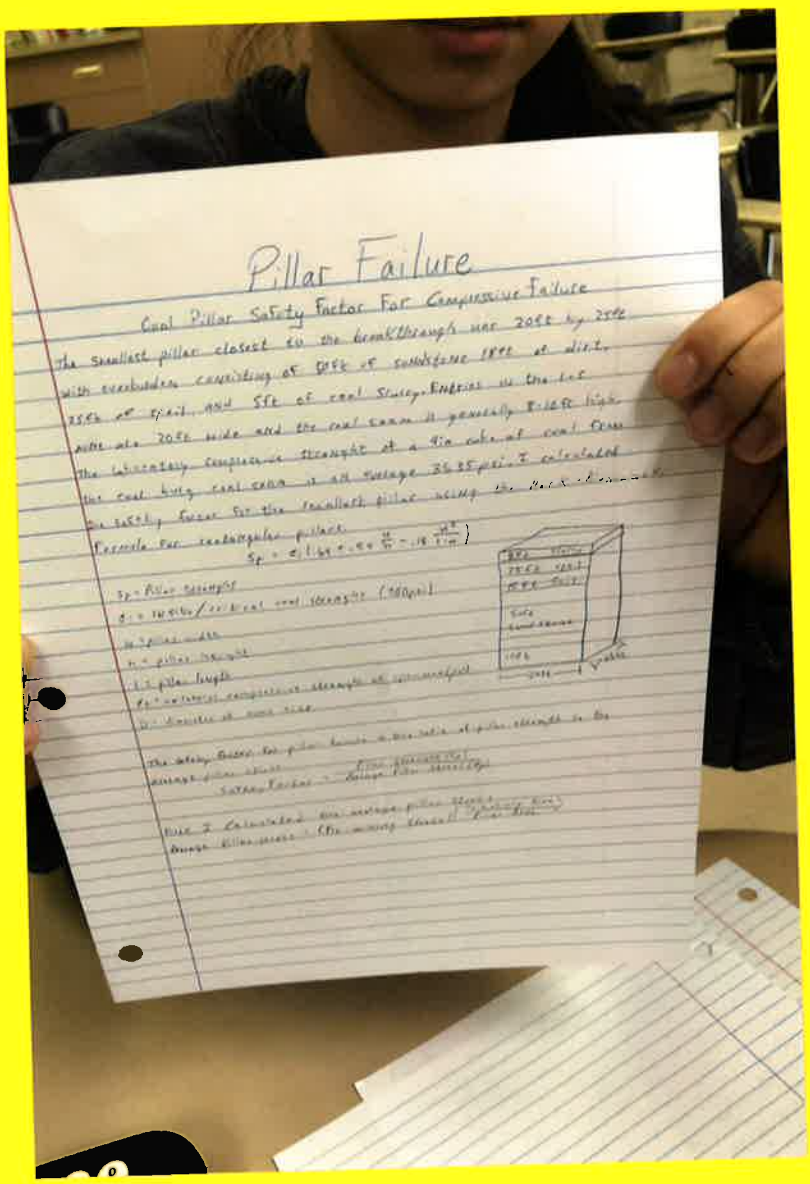
Activity #3

This is a group that is designing and solving a problem using the polygonal method to estimate the volume and value of the coal on our property. They also estimated the height of the coal seam directly below a coal slurry pond that would be located on the surface above our mine. This group Inverse Distance to a Square to estimate the height of the coal seam.

CSU #
03-05-19

Activity #4

We asked some our students to work with a partner and determine weather a coal slurry pond can safely be located on our property and over top of our model underground coal mine. This group came up with a safety factor of 5.3 at a depth of 95 ft



Activity #5

This activity was probably the one that was the most fun for our students. We recruited a group of 12 students to design and build our model underground in an empty JROTC classroom. They did a great job. The mine has 2 entries and 1 break. It also has a mine fan for ventilation

Activity #6

This group of students estimated the volume of the coal in our coal seam using Delaney Triangulation. They also estimated the volume of the coal using the Surfer 8 3-D Modeling Software. The 2 estimations were amazingly close. They also generated some 2-deminsioal and 3-deminsional pictures of the coal seam using Surfer 8.

CSU #
03-05-19

Activity #7

Our students had a lot fun with this activity. We simulated a roof fall in our model mine. We then sent a robot into the mine with a light and a cell phone attached to locate the roof fall. The cell phone sent back live video via Skype. We then sent in our mine rescue team with a first aid kit to locate and remove survivors of the fall. The rescue team wore a headlamp to provide lighting because we turned out the lights! The kid's loved this activity.

CSU #
03-05-19

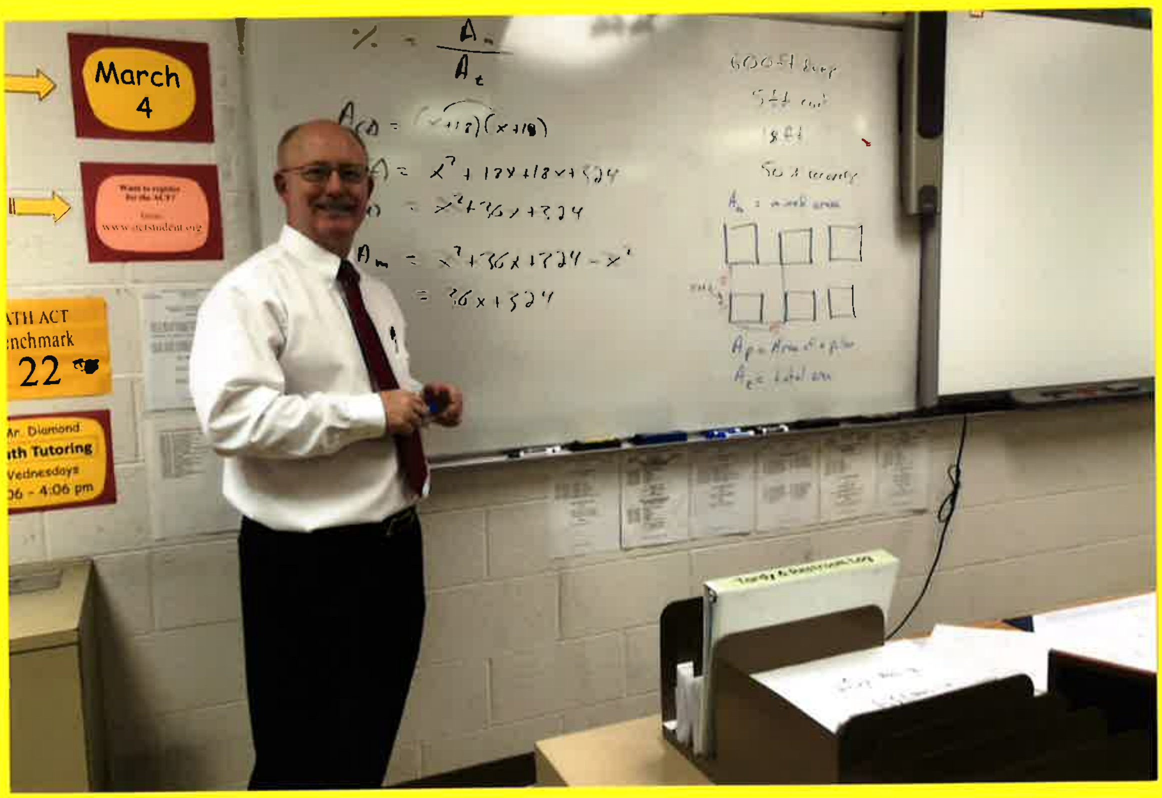
Activity #7b

The second part of this activity involved the simulated mine rescue of the injured roof fall victim. After the robot located the victim we sent in our mine rescue team, performed first aid, and brought out the injured miner. The injured miner was actually a stuffed animal that one of our students provide for this activity. Someone named the injured victim "Mighty Miner Dog". Here you see the rescue team exiting the mine with the injured casualty. The lights were out during the recue…just like in a real coal mine.

CSU #
03-05-19

Activity #8

In this activity I led a discussion with entire class about the importance of adequate roof support. I also modeled for the class how to correctly estimate the minimum size coal pillars that we would need to support the roof in our mine.



CSU #
03-05-19

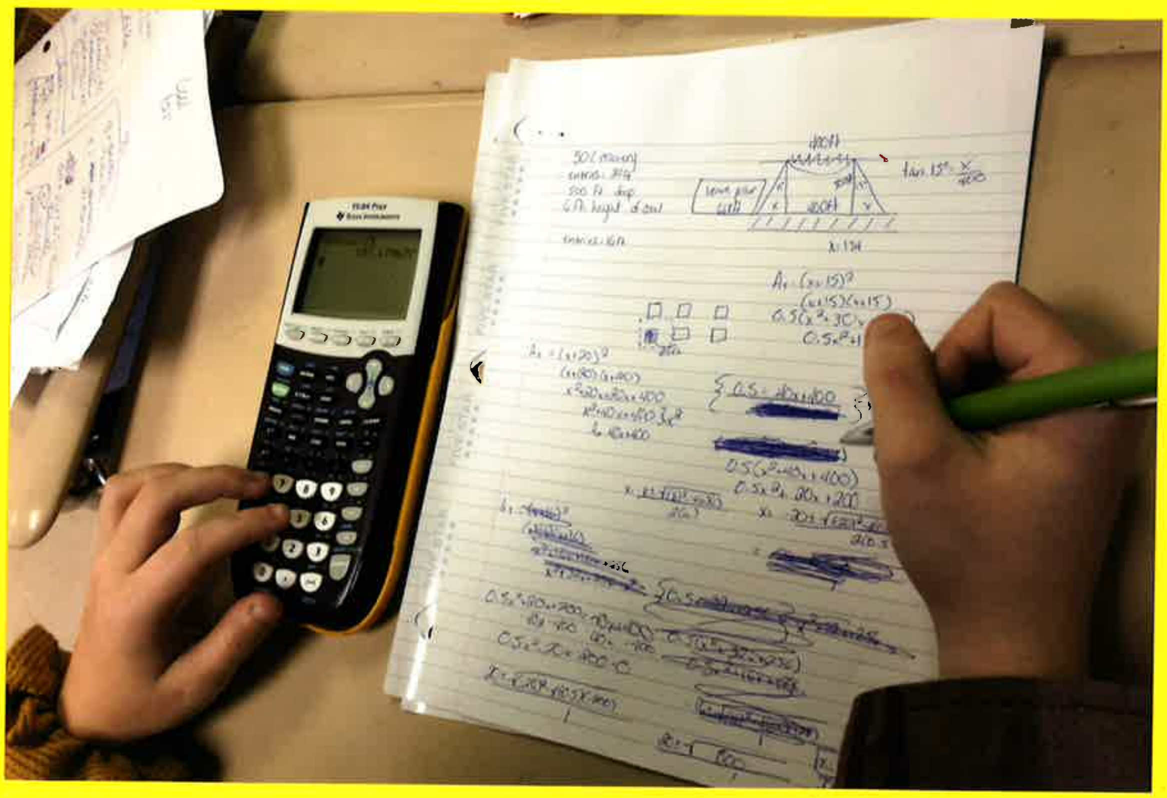
Activity #9

Here, students were placed in groups and were asked to design and solve at least one problem involving minimum pillar size for an underground coal mine. They also had to calculate the Safety Factor for our model coal mine if we were to use their recommended pillar width.

CSU #
03-05-19

Activity #10

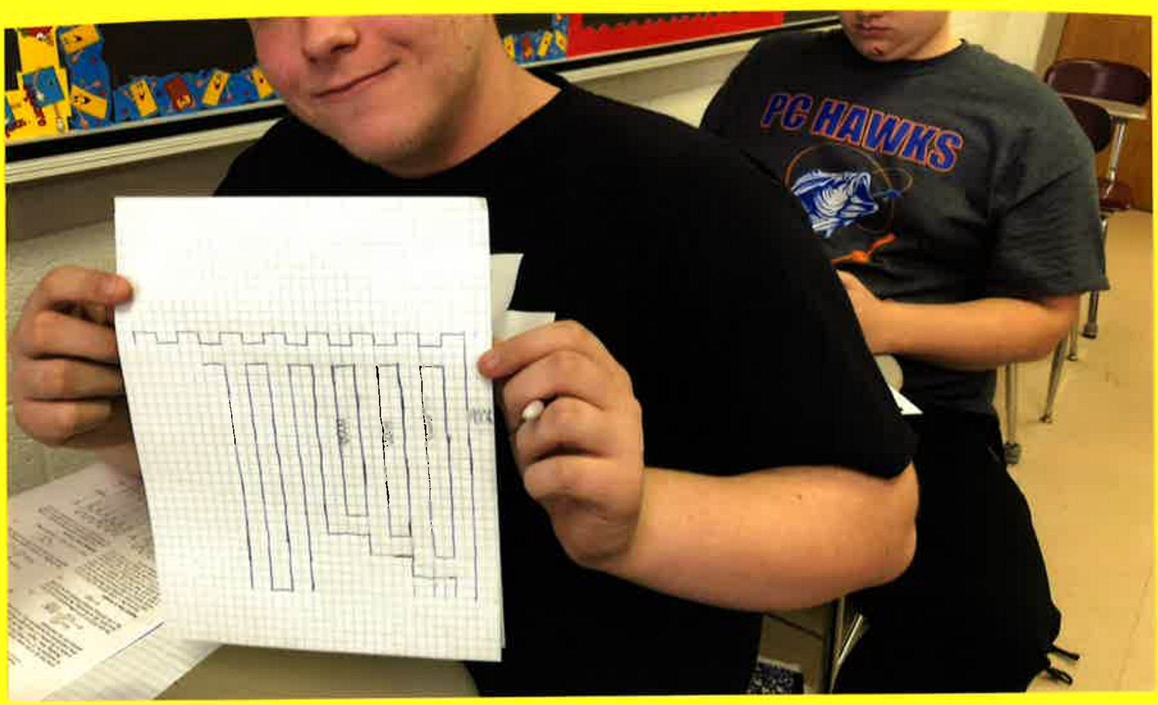
We had several groups of students calculating the minimum diameter of the roof bolts that we would use in our model mine. This group calculated that we would need at least 0.25 inch. This is a very reasonable estimate.



CSU #
03-05-19

Activity #12

In this activity, students were placed in groups and asked to design the ventilation schematic for our mine. They had to take into consideration that the mine would increase in size with more entries and breaks. They also determined the impact of pressure change on the ventilation system of our mine.



Activity #13

After the coal is removed from the mine, our science students then took the mined coal and determined it's ash, moisture, sulfur, and BTU content. This would be very important information if we were to sell the coal.

CSU #
03-05-19

Activity #14

Here you see students from our social studies classes in the library researching a specific topic concerning the history of coal mining. These students were to emphasize the impact of coal mining on the development of communities in the region .

CSU #
03-05-19

Activity #15

Our Food Service students made a pudding dish composed of 3 layers of pudding. Two layers were made of vanilla pudding and the middle layer was made from chocolate pudding. The 3 layers together modeled the coal seam in our mine and the rock layers above and below our coal seam.

Activity #16

In this activity, the students in our music classes are writing and/or performing a song about coal mining.

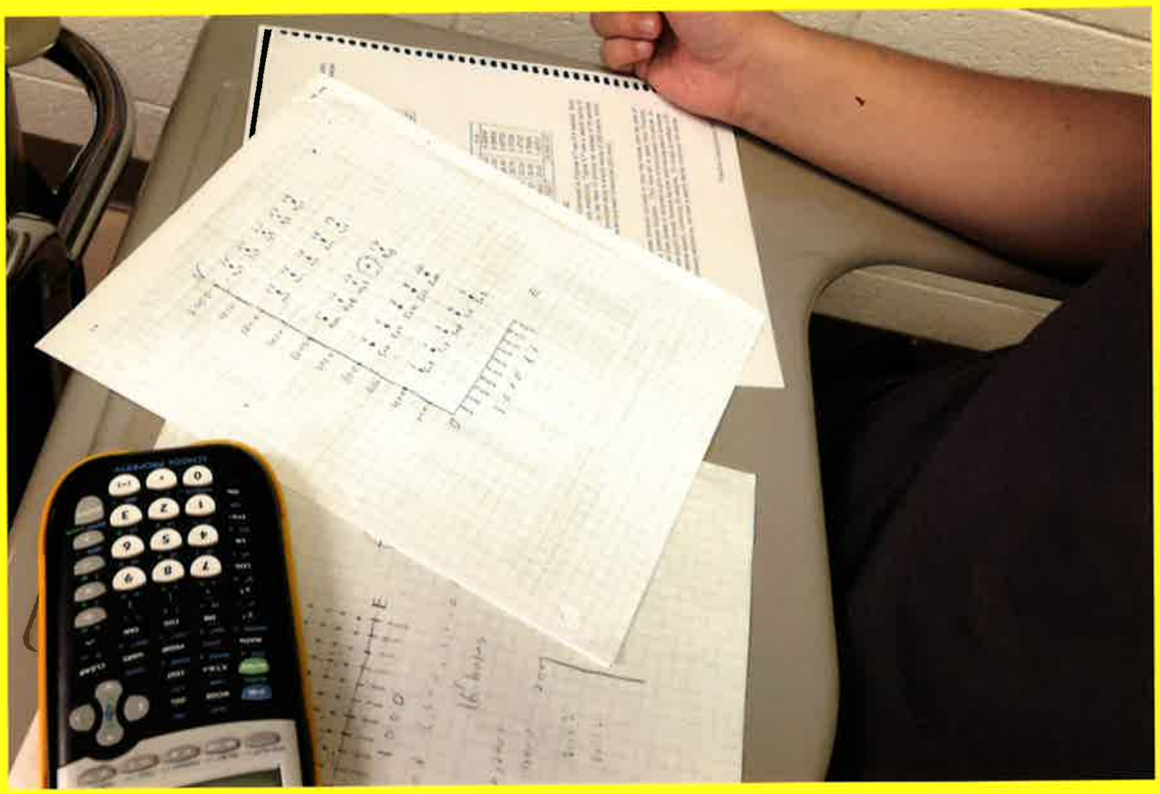
Activity #17

In this activity you see students in our art classes producing pieces of 2-D and 3-D works of art with coal mining as the central theme. These pieces of art were displayed in the library at our school for the school community to enjoy.

CSU #
03-05-19

Activity #18

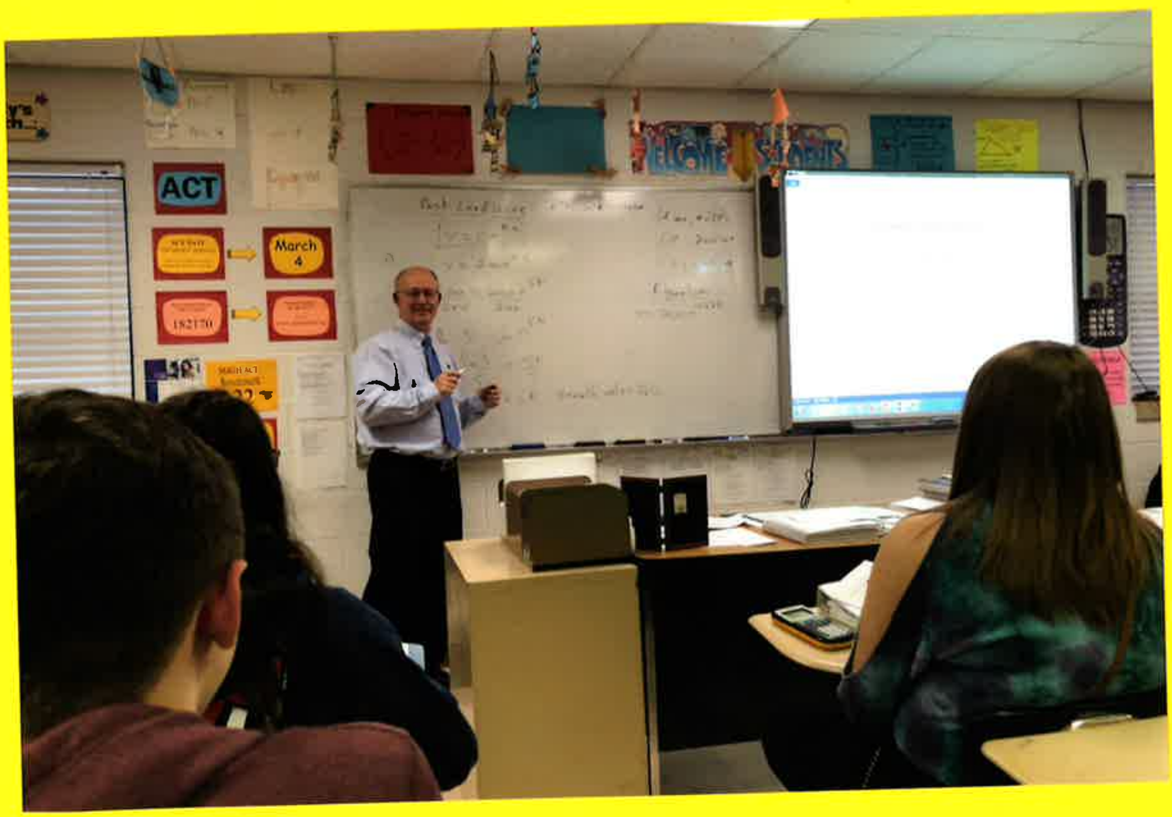
Here we see a group of students designing and solving a problem involving the statistical estimation of the number of trees on our property after the land has been reseeded. This group has their land track developed and are ready to perform the necessary calculations.



CSU #
03-05-19

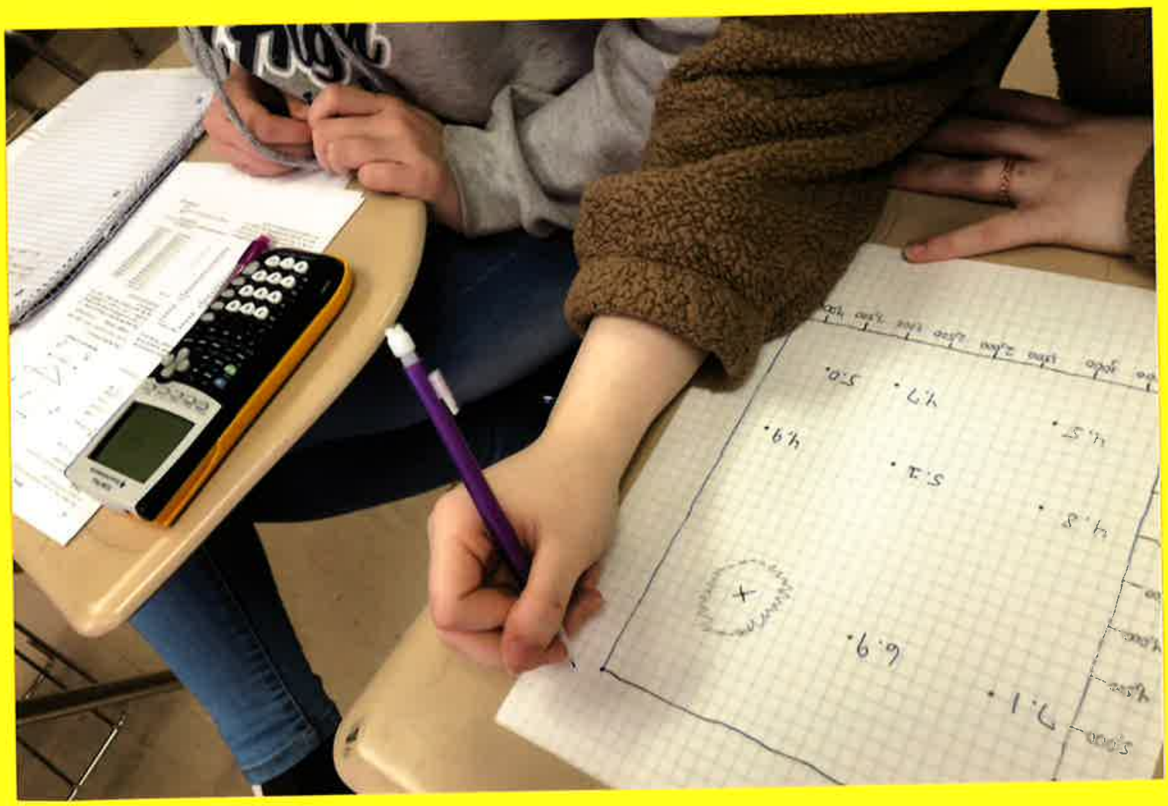
Activity #19

In this activity, I am demonstrating to my Precalculus classes how to use exponentials and logarithms in predicting a population of elk that has been relocated to the abandoned strip mine that is located on the surface of our property.



Activity #20

Students you see in this activity are designing a problem that will model the amount of time it will take for the transplanted elk heard to reach its maximum carrying capacity on our reclaimed surface mine. These students also developed a rubric that can be used in grading their problem.



Activity #21

When I asked my classes how we could use our model coal mine to make some money. They displayed their entrepreneurial talents by suggesting that we charge a fee to "tour' our mine. The proceeds would go to support of band program at our school. We quickly dropped the fee to see our mine and invited the entire school community to see it for free.

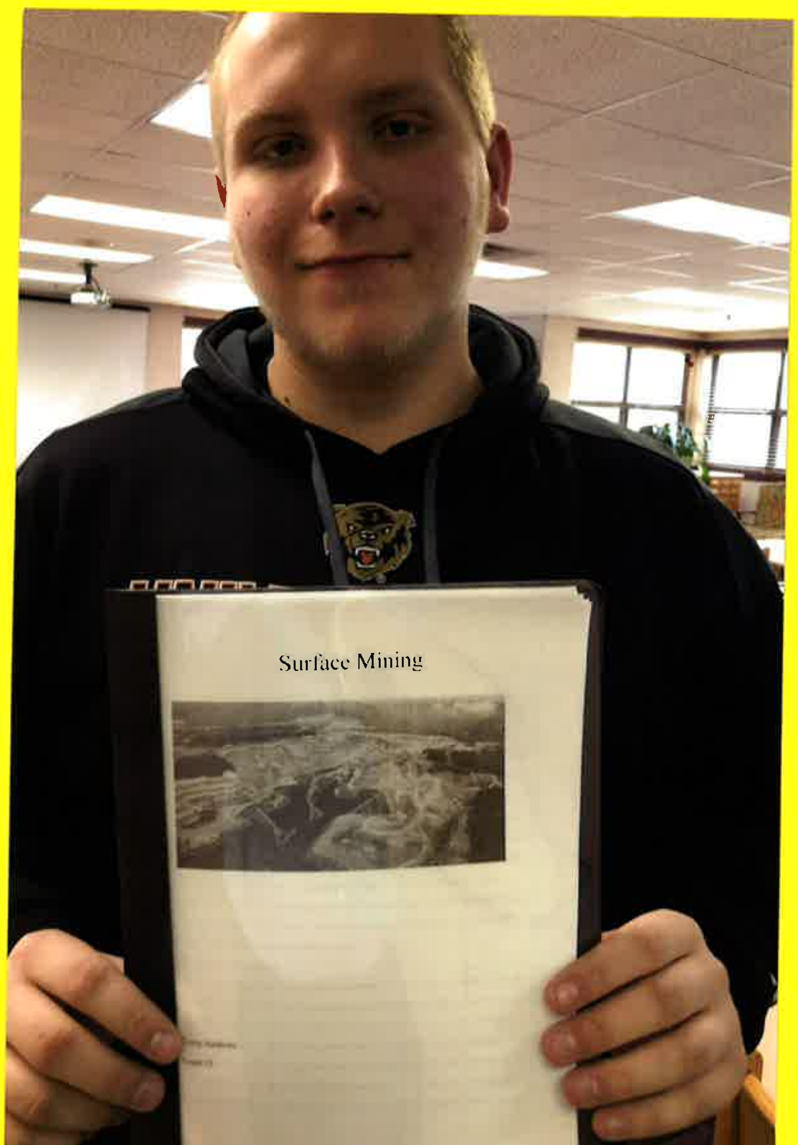
Activity #22

Another activity that allowed our students to demonstrate their ability to make money from our model mine involved getting our art students to paint the coal that we "produced" from our mine. They first put on a layer of glaze and painted their piece of coal. These pieces of art will be sold in a silent auction later this year and the proceeds will be use to support our band.

CSU #
03-05-19

Activity #23

Here you see one of our senior English students displaying his essay about surface mining. The senior English classes went to the computer lab and produced an essay, short story, or poem with coal mining as the central theme.



CSU #
03-05-19

Activity #24

This was an extra activity that one my students suggested we do with our model mine after we built it. This was not in our original plan but I believe that our unit is student directed so we did the activity. The student suggested that we turn off the lights and have each student put on the headlamp and spend some time in our mine. It allowed each of our students to see what it would be like to be underground in a real coal mine. It also showed how difficult it is to be a coal miner. This was great activity

Activity #25

This was the 2nd activity initiated by our students and it was completely unanticipated. Our model underground coal mine became a student "hang out" at our school. Our students would sit in the mine during break and eat snacks and listen to music. They said that it was like being in a 4 foot high tent. Like I said, our students loved our model underground coal mine.

The Summary

III. SUMMARY

We finally completed our last activity and it was time to evaluate whether or not the unit was a success. I began by asking for feedback from my fellow teachers. We discussed which activities were successful and what we would change about the unit if we get to teach this same unit again. The fact that the robotics team was not able to participate in our Mine Rescue Simulation was the only disappointment that we experienced with this unit. I also asked my math students to help me evaluate our unit. I used two techniques to receive feedback from my students. First, I asked them to fill out a survey where they listed some things they liked about the unit, ways to improve the unit, and some general comments about the unit. Every single student who took the survey said that they enjoyed participating in the unit and most did not want the unit to end. Second, I lead a class discussion with my mathematics students about our unit. This year I began the discussion by asking the students to draw parallels between the model underground coal mine that we built at our school and a real coal mine. The first thing that one of my students noted about our model underground coal mine was that it has been closed down... just like many of the mines in our area.

I have to say that this was a great unit! We found that just one piece of property in our area can contribute greatly to the quality of life of the area residents. It also can have tremendous economic benefits to our local economy. Area miners can be employed on the surface or underground to remove the coal located on the property. These are high paying jobs that support miners and their families. These jobs also support local businesses, schools, and state and local governments by providing a good tax base.

We discovered that even after the property has stopped producing coal, it can still continue to contribute to the quality of life of the residents in the area by providing level land that can be utilized by local governments for economic development. Even abandoned mine property in rural areas can be valuable by providing wildlife habitat for small and large game animals. Elk herd that we see in Eastern Kentucky were originally transplanted onto abandoned surface mine property.

Everyone agrees that this unit was the best CEDAR unit that we have ever taught at our school. It was AWESOME. Building the mine and the mine rescue simulation was definitely most everyone's favorite activities. It showed how valuable one piece of property can be by providing good mining jobs and making level land available to the community after the mines have closed. Our unit involved the active participation of eighteen teachers, our guest engineer, and approximately 366 students.

The participating teachers and students believe that the unit met or exceeded the overarching goal and completely answered the one essential question that we had envisioned for our unit. It was apparent to participants and stakeholders that this unit became much more than we anticipated when the teachers and students originally came up with the idea of building a model mine at our school. Most importantly, the students loved this unit, they had fun, and they learned a lot about how one piece of property can impact a community.

Participating teachers in each department used multiple methods to evaluate their students. These include formative evaluations such as open-response questions, oral feedback, quizzes, and exit slips. They also used summative evaluations such as culminating activities and group project products.

The activities taught in this unit were designed to allow students the opportunity to learn in the type of multiple-intelligence and learning style that best suited their needs. These styles included linguistic, logical mathematical, spatial, musical, bodily-kinesthetic, interpersonal, and intrapersonal. All the participating teachers were able to differentiate their instruction to meet the needs of students containing IEP modifications. These include special education students, 504 students, and students in our gifted and talented program.

In conclusion, one of our students came up with an activity that involved having each member of the class take turns putting on a headlamp, turning out all the lights, and going back into the model mine. She suggested that this would "fun." So, we had each of our students get on their hands and knees and go back into our mine. After bumping their heads on the ceiling a few times, most students wanted out after just a few minutes.

An important lesson that we wanted our students to take away from our Coal Unit and our model underground coal mine was that mining is a difficult and dangerous job, and thanks to a suggestion from one of our students, this is a lesson that our students will never forget.

Student Feedback and Reflection

List three things that you liked about our coal study unit.

1. I liked using the drill to make the mine

2. I liked sitting in the mine

3.

Is there anything that we can do to improve the unit?

1. Lets make a bigger mine

2.

Would like to make any comments about our unit?

____

____

____

____

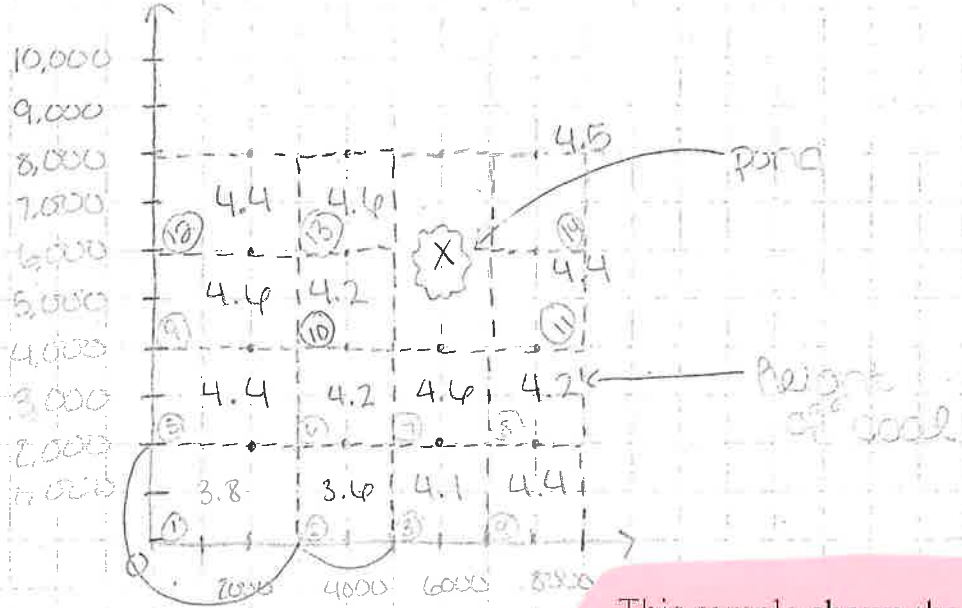
This is a student copy of the form that I use to get feedback from my students after our unit is finished. We also discuss the activities as a large group. This feed back is very helpful in evaluating our unit.

Samples of Student Work

Each sample will be shown with a numbered green dot to indicate which activity it goes with.

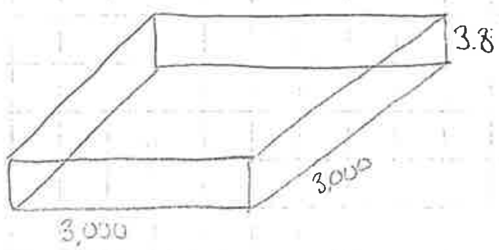
CSU #
03-05-19

1



This sample **shows** the groups land tract and their calculations using the Polygonal Method to **estimate** the tons of coal that is **located** on our **piece** of property. This group did not calculate the value of the coal.

Polygonal method



(1) $V = l \cdot w \cdot h$
$V = (3{,}000)(3{,}000)(3.8)$
$= 34{,}200{,}000$ ft

(2) $V = l \cdot w \cdot h$
$= (2{,}000)(2{,}000)(3.6)$
$= 14{,}400{,}000$ ft

(3) $V = l \cdot w \cdot h$
$= (2{,}000)(2{,}000)(4.1)$
$= 16{,}400{,}000$ ft

(4) $V = l \cdot w \cdot h$
$= (2000)(2000)(4.4)$
$= 17{,}600{,}000$ ft

(5) $V = l \cdot w \cdot h$
$= (3{,}000)(3000)(4.4)$
$= 39{,}600{,}000$ ft

(6) $V = l \cdot w \cdot h$
$= (2000)(2000)(4.2)$
$= 16{,}800{,}000$ ft

(7) $V = l \cdot w \cdot h$
$= (2000)(2000)(4.6)$
$= 18{,}400{,}000$ ft

(8) $V = l \cdot w \cdot h$
$= (2000)(2000)(4.5)$
$= 18{,}000{,}000$ ft

(9) $V = l \cdot w \cdot h$
$= (3000)(3000)(4.6)$
$= 41{,}400{,}000$ ft

(10) $V = l \cdot w \cdot h$
$= (2000)(2000)(4.2)$
$= 16{,}800{,}000$ ft

(11) $V = l \cdot w \cdot h$
$= (2000)(2000)(4.4)$
$= 17{,}600{,}000$ ft

(12) $V = l \cdot w \cdot h$
$= (3000)(3000)(4.4)$
$= 39{,}600{,}000$ ft

(13) $V = l \cdot w \cdot h$
$= (2000)(2000)(4.6)$
$= 18{,}400{,}000$ ft

(14) $V = l \cdot w \cdot h$
$= (2000)(2000)(4.5)$
$= 18{,}000{,}000$ ft

Drill hole	height of coal	x-coordinate	y-coordinate
1	3.8	2000	2000
2	3.6	4000	2000
3	4.1	6000	2000
4	4.4	8000	2000
5	4.4	2000	4000
6	4.2	4000	4000
7	4.6	6000	4000
8	4.5	8000	4000
9	4.6	2000	6000
10	4.2	4000	6000
11	4.4	8000	6000
12	4.4	2000	8000
13	4.6	4000	8000
14	4.5	8000	8000

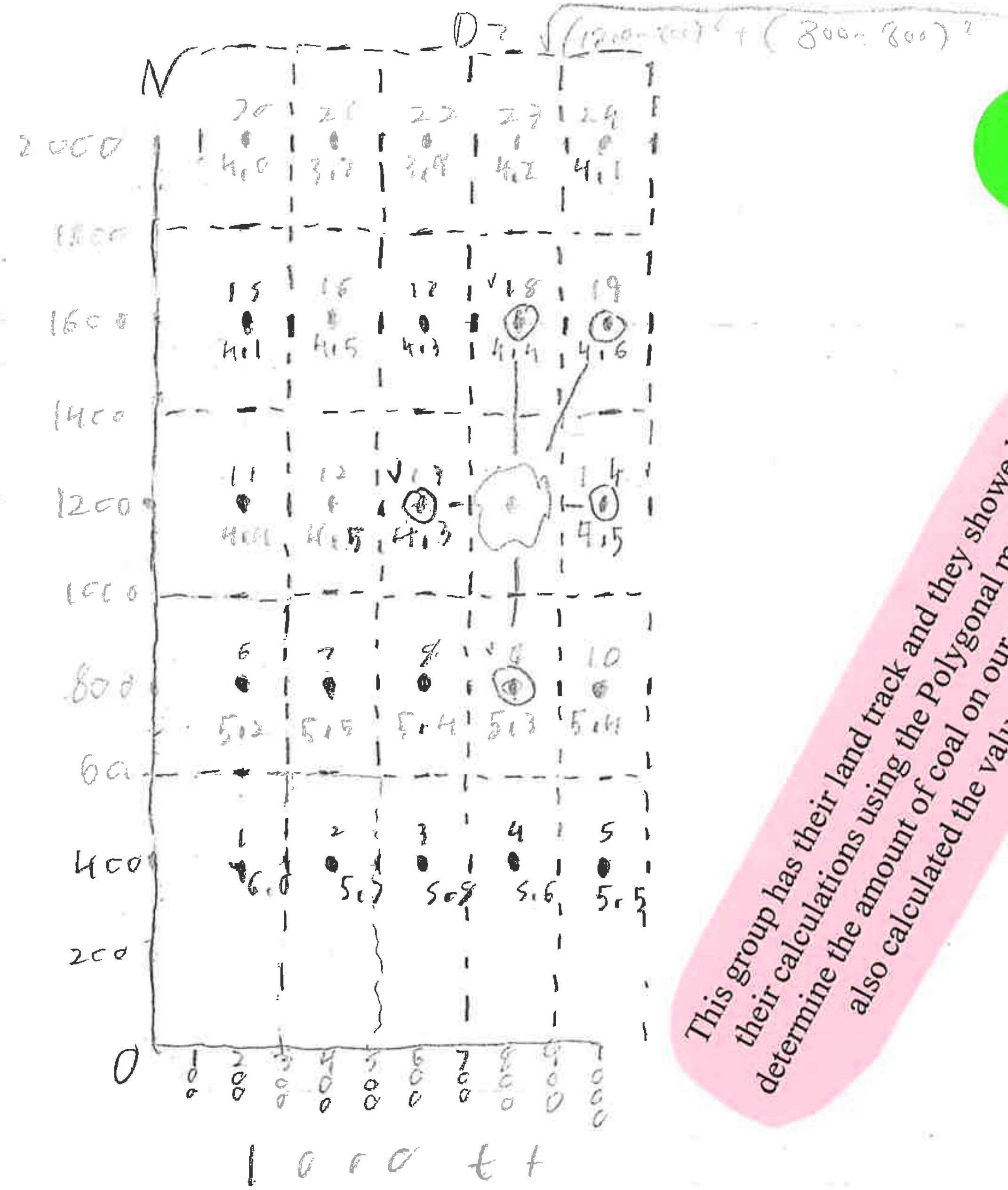
Drill hole	l · w · h	Volume
1	(9,000,000)(3.8)	34,200,000ft
2	(4,000,000)(3.6)	14,400,000ft
3	(4,000,000)(4.1)	16,400,000ft
4	(4,000,000)(4.4)	17,600,000ft
5	(9,000,000)(4.4)	39,600,000ft
6	(4,000,000) (4.2)	16,800,000ft
7	(4,000,000)(4.6)	18,400,000ft
8	(4,000,000)(4.5)	18,000,000ft
9	(9,000,000)(4.6)	41,400,000ft
10	(4,000,000)(4.2)	16,800,000ft
11	(4,000,000)(4.4)	17,600,000ft
12	(9,000,000)(4.4)	39,600,000ft
13	(4,000,000)(4.6)	18,400,000ft
14	(4,000,000)(4.5)	18,000,000ft
	= 76,000,000 sq ft	= 327,800,000 cu ft

Convert to tons

327,800,000 cu ft × 0.04 tons/cu ft

= 13,088,000 tons

1



This group has their land track and they showed all their calculations using the Polygonal method to determine the amount of coal on our property. They also calculated the value of our coal.

	N	E	Coal		N	E	Coal		N	E	Coal		N	E
1.	400	200	6.0	8.	800	600	5.4	15.	1600	200	4.1	22.	2000	600
												Coal	3.9	
2.	400	400	5.7	9.	800	800	5.3	16.	1600	400	4.5	23.	2000	800
												Coal	4.2	
3.	400	600	5.8	10.	800	1000	5.4	17.	1600	600	4.3	24.	2000	1000
												Coal	4.1	
4.	400	800	5.6	11.	1200	200	4.4	18.	1600	800	4.4			
5.	400	1000	5.5	12.	1200	400	4.5	19.	1600	1000	4.6			
6.	800	200	5.2	13.	1200	600	4.3	20.	2000	200	4.0	Pond:	1200	900
7.	800	400	5.5	14.	1200	1000	4.5	21.	2000	400	3.7			

L x W x H

#1:

Drill Hole	Length of Coal	Height	Width	Cubic feet
1	300	6.0	600	1,080,000 Cu Ft
2	200	5.7	600	684,000 Cu Ft
3	200	5.8	600	696,000 Cu Ft
4	200	5.6	600	672,000 Cu Ft
5	100	5.5	600	330,000 Cu Ft
6	300	5.2	400	624,000 Cu Ft
7	200	5.5	400	440,000 Cu Ft
8	200	5.4	400	432,000 Cu Ft
9	200	5.3	400	424,000 Cu Ft
10	100	5.4	400	216,000 Cu Ft
11	300	4.4	400	528,000 Cu Ft
12	200	4.5	400	360,000 Cu Ft
13	200	4.3	400	344,000 Cu Ft
14	100	4.5	400	180,000 Cu Ft
15	300	4.1	400	492,000 Cu Ft
16	200	4.5	400	360,000 Cu Ft
17	200	4.3	400	344,000 Cu Ft
18	200	4.4	400	352,000 Cu Ft
19	100	4.6	400	184,000 Cu Ft
20	300	4.0	200	240,000 Cu Ft
21	200	3.7	200	148,000 Cu Ft
22	200	3.9	200	156,000 Cu Ft
23	200	4.2	200	168,000 Cu Ft
24	100	4.1	200	82,000 Cu Ft
25	200	4.5	400	360,000 Cu Ft
			Total	9,896,000 Cu Ft

Tennage = 9,896,000 x 0.04

395,840 tons x 99 Per ton

$39,168,160 dollars

CSU #
03-05-19

4

Safety factor for Slurry Pond at 95 ft

Solving For Pre-mining Stress (psi)

σ_v = [(weight of water ($\frac{lb}{ft^3}$) * specific gravity * depth (ft)]

Specific Gravity
Sandstone = 2.7
Soil = 2.0
spoil = 1.6
Slurry = 1.40

Stress from the Sandstone

$\sigma_v = 62.4 \frac{lb}{ft^3} * 2.7 * 50ft \longrightarrow \sigma_v = 8424 \frac{lb}{ft^2}$

Stress from the Soil

$\sigma_v = 62.4 \frac{lb}{ft^3} * 2.0 * 15ft \longrightarrow \sigma_v = 1872 \frac{lb}{ft^2}$

Stress from the spoil

$\sigma_v = 62.4 \frac{lb}{ft^3} * 1.6 * 25ft \longrightarrow \sigma_v = 2496 \frac{lb}{ft^2}$

Stress from the Slurry

$\sigma_v = 62.4 \frac{lb}{ft^3} * 1.40 * 5ft \longrightarrow \sigma_v = 436.8 \frac{lb}{ft^2}$

The pre-mining stress is the sum of each layer of overburden in pounds per square inch.

$= \left(8424 \frac{lb}{ft^2} + 1872 \frac{lb}{ft^2} + 2496 \frac{lb}{ft^2} + 436.8 \frac{lb}{ft^2}\right)\left(\frac{1 in^2}{144 ft^2}\right)$

$= 92 psi$

Average Pillar Stress $= (92 psi)\left(\frac{(20ft + 20ft)(25ft + 20ft)}{(20ft)(25ft)}\right)$

Average Pillar stress = 331 psi

Next I calculated the critical coal strength (σ_i) of a four inch cube of Coalburg coal.

$\sigma_i = \frac{\text{Lab compressive strength} * \sqrt{\text{side of cube}}}{\sqrt{36}}$

$\sigma_i = \frac{3535 psi * \sqrt{4}}{\sqrt{36}}$

$\sigma_i = 1178.3 psi$

This group determined weather a slurry pond can be safely located over top of our mine. They calculated the vertical pressure from the overburden determined that the pond would have a safety factor of 5.1 if the pond was 95 feet above the mine. This is safe.

$$\text{Pillar Strength } (S_p) = \sigma_1 \left(.64 + .54 \frac{W}{h} - .18 \frac{W^2}{l \cdot W}\right)$$

$$\text{Pillar Strength } (S_p) = 1178.3\,psi \left(.64 + .54 \left(\frac{20\,ft}{10\,ft}\right) - .18 \left(\frac{(20\,ft)^2}{25\,ft \times 20\,ft}\right)\right)$$

$$\text{Pillar Strength } (S_p) = 1178.3\,psi\,(1.432)$$

$$\text{Pillar Strength } (S_p) = 1687.4\,psi$$

$$\text{Safety Factor} = \frac{S_p}{\sigma_p} = \frac{\text{Pillar Strength}}{\text{Average Pillar Stress}}$$

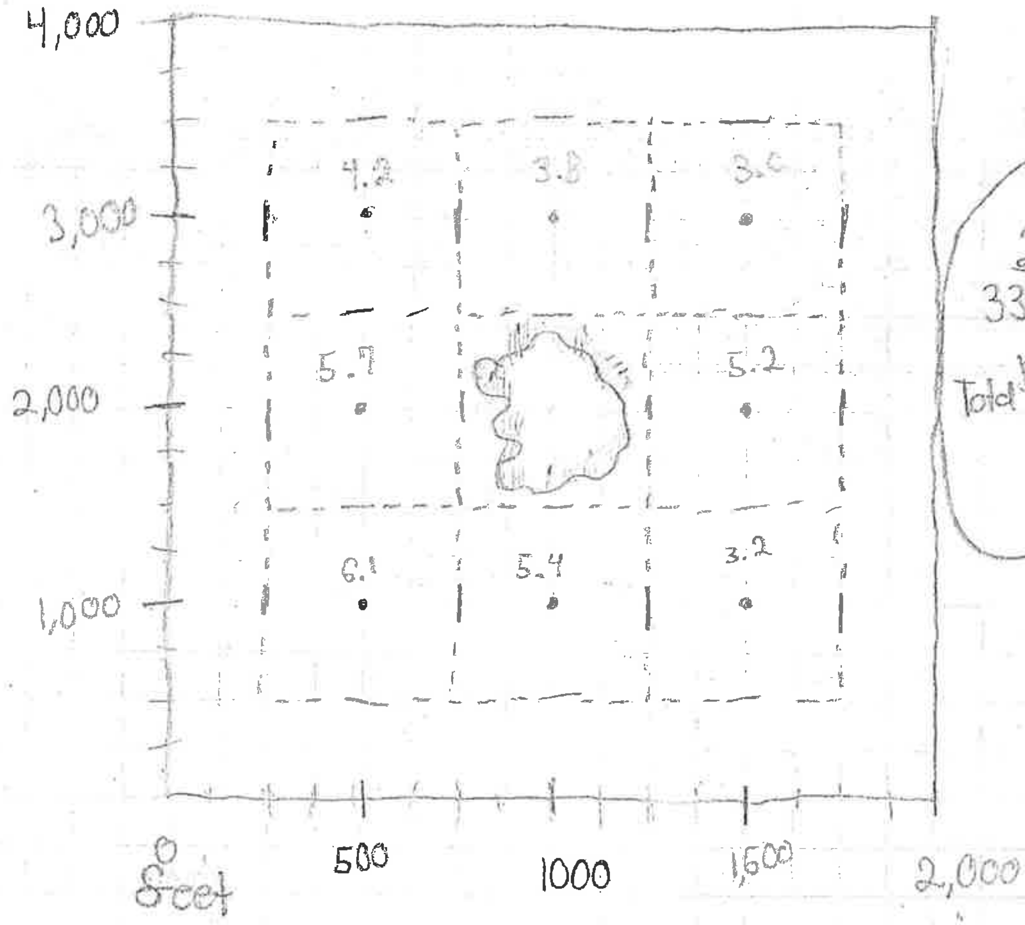
$$\text{Safety Factor} = \frac{1687.4\,psi}{331\,psi}$$

$$\text{Safety Factor} = 5.10$$

← This is very safe. No pillar failure in our mine.

Karsyn & Leah

6



1

6

2017 Coal price
33.72 per short ton
Total 14229840$

CSU #
03-05-19

2

	Drill hole	Seam thickness	East	North	volume
1	(bottom left)	6.1	1000	2000	1525000
2		5.4	1000	1000	1350000
3		3.2	1500	1000	800000
4		5.7	500	2000	1,425,000
5	Pond →				
6		5.2	1500	2000	1300000
7		4.2	500	3000	1,050,000
8		3.8	1000	[illegible]	950000
9	(Top right)	3.6	1500	3000	900000

back

Total
10550000 ft^3

This group used the Polygonal method to determine the amount of coal on our property. They used Delauney Triangulation to estimate the height of the coal seam at a point below a coal slurry pond located overtop of our mine. They also used the Surfer 8 Software to estimate the volume of coal in the coal seam.

Grid Volume Computations

Mon Feb 18 14:27:05 2019

Upper Surface

Grid File Name:	C:\Users\gdiamond\Desktop\Leah and Karsyn.grd
Grid Size:	100 rows x 51 columns
X Minimum:	500
X Maximum:	1500
X Spacing:	20
Y Minimum:	1000
Y Maximum:	3000
Y Spacing:	20.20202020202
Z Minimum:	3.2000000062227
Z Maximum:	6.0892412652131

Lower Surface

Level Surface defined by Z = 0

Volumes

Z Scale Factor: 1

Total Volumes by:

Trapezoidal Rule:	10234824.880411
Simpson's Rule:	10235014.216421
Simpson's 3/8 Rule:	10235011.7038

← This is very close to the groups estimation.

Great Job!

Cut & Fill Volumes

Positive Volume [Cut]:	10234764.584359
Negative Volume [Fill]:	0
Net Volume [Cut-Fill]:	10234764.584359

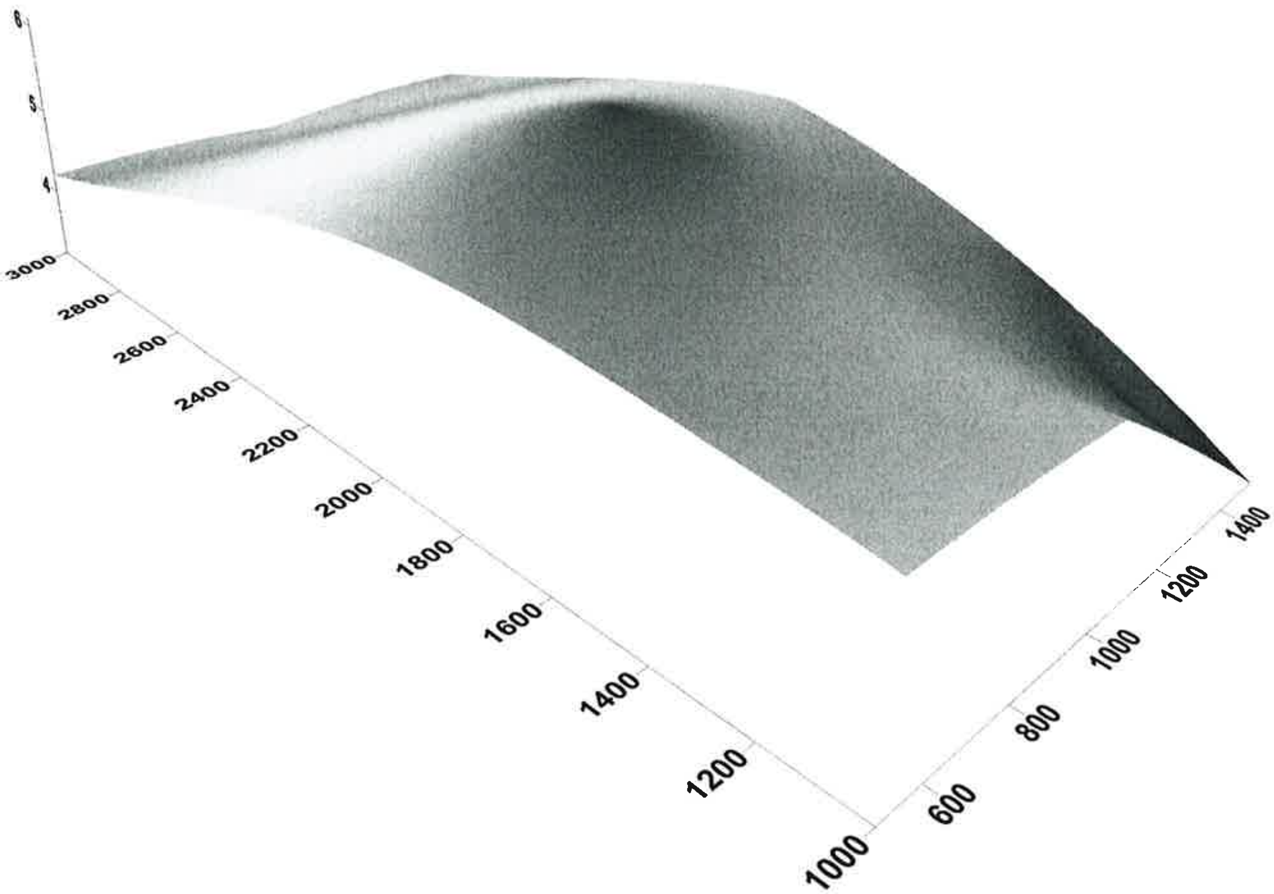
Areas

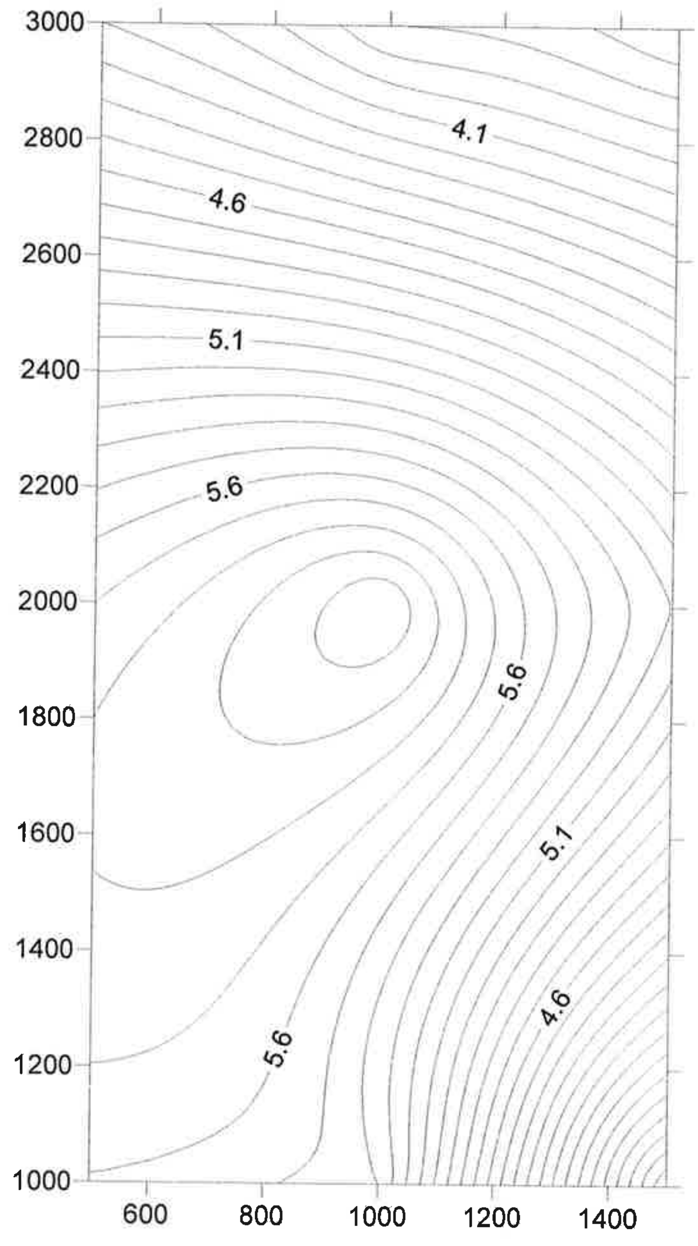
Planar Areas

Positive Planar Area [Cut]:	2000000
Negative Planar Area [Fill]:	0
Blanked Planar Area:	0
Total Planar Area:	2000000

6

A student generated 3-dimensional picture of our coal seam using the Surfer 8 Modeling Software.

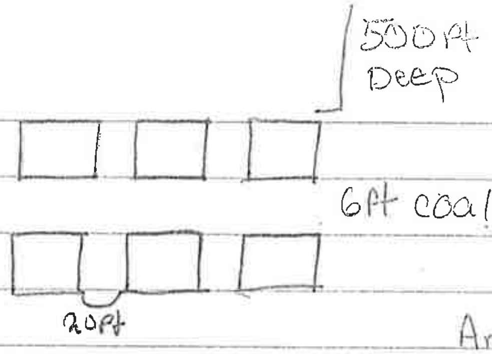




A student generated 2-dimensional picture of our coal seam using the Surfer 8 Modeling Software.

9

50% recovery
500 ft deep
20ft entry ways
6ft high coal



Am = mined area
At = total area
Ap = Area of pillar

$$\% = \frac{Am}{At}$$

At

$A(t) = (x+20)(x+20)$
$= x^2 + 20x + 20x + 400$
$A(t) = x^2 + 40x + 400$

Am

$A(m) = (x^2 + 40x + 400) - x^2$
$A(m) = 40x + 400$

%

$50\% = \frac{40x + 400}{x^2 + 40x + 400}$

$.5 = \frac{40x+400}{x^2+40x+400}$

$\times\ x^2+40x+400 \qquad \times\ x^2+40x+400$

$.5x^2 + 20x + 200 = 40x + 400$
$\quad -40x - 400 \quad -40x - 400$

$.5x^2 - 20x - 200$

quadratic formula

$$= \frac{-(-20) \pm \sqrt{(-20)^2 - 4(.5)(-200)}}{2(.5)}$$

$$= \frac{+(20) \pm \sqrt{(-20)^2 - 4(.5)(-200)}}{2(.5)}$$

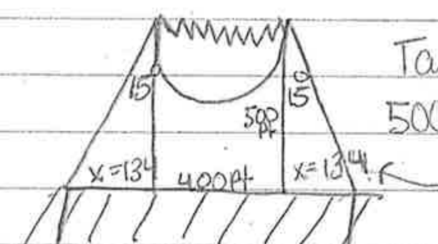
$$= \frac{20 \pm 28.3}{1}$$

$\frac{20 + 28.3}{1}$ $\qquad$ $\frac{20 - 28.3}{1}$

$= 48.3$ ft $\qquad$ ~~$= -8.3$~~

Ap = 48.3 ft

Offset distance



$\tan 15° = \frac{x}{500ft}$
$500 \tan 15° = x$
$x = 133.9$

400ft + 134ft + 134ft
= 668 ft

Offset distance
= 668ft
668ft pillar must be left

This group determined the minimum size of the pillars for our mine if the mine is 500 ft deep and the coal seam is 6ft high. They also found the safety factor of the mine to be 2.2. Very safe.

Maximum Pillar Size and Safety Factor

6ft coal height
500ft depth
2.5 gravity
3500 psI compressor
4in cubes

K = compressor strength × $\sqrt{\text{cubic inch of coal}}$
h = height of coal × 12in
w = width of pillar × 12in
psI = per square inch
62.4 = weight of water

Average pillar ~~strength~~ stress

$$\frac{(\text{Depth})(\text{gravity})(62.4)}{(12)^2} \times \frac{\text{Tributary}}{\text{pillary}}$$

$$\left[\frac{(500)(2.5)(62.4)}{144}\right] \times \left[\frac{(68.3)^2}{(48.3)^2}\right]$$

$541.7 \times 2 = 1083.4$ psI

Pillar strength

$$\frac{K\sqrt{w}}{h}$$

$K = 3500 \times \sqrt{4} = 7000$

$$\frac{7000\sqrt{48.3 \times 12}}{(6 \times 12)}$$

$= 2340.6$ psI

Safety factor Holland-gaddy

$$SF = \frac{\text{Pillar strength}}{\text{average pillar strength}}$$

$$SF = \frac{2340.6}{1083.4}$$

Safety Factor = 2.2

Is the safety factor between 1.8 - 2.2?

yes!

The mine is safe to work in!

Excellent!

CSU #
03-05-19

10

Calculating the size of My Roof Bolts

In our coal mine, we have an 8ft high seam of coal lying beneath a moderately fractured seam of 6ft thick shale. The depth of the mine is 600ft. The weight of shale is 170lb per ft³. Above the shale is a large bed of sandstone. The entries are 16ft wide and 20ft cut. Each cut has 5 row. We want a safety factor use 50 grade steel.

This group calculated the diameter of the roof bolts that would needed for our mine if the mine were 600 ft deep and the coal seam was 6 ft high. They recommended 0.75 inch roof bolts.

$$\text{Load per bolt} = \frac{(\text{weight of roof})(\text{beam thickness})(\text{Span Width})(\text{Length of Cut})}{(\#\text{ of rows}+1)(\#\text{ of bolts per road}+1)}$$

$$\frac{(170)(6)(16)(20)}{(6)(5)} = \frac{326,400}{30} = 10,880\text{lb per bolt}$$

$$\frac{(\text{Load per bolt})(\text{safety factor})}{(\text{grade of steel})} = \frac{(10,880)(2)}{50,000} = 0.432\text{in}^2$$

The area of a circle is $A=\pi r^2$.

$0.432 \div \pi = 0.138$

$\sqrt{0.138} = \sqrt{r^2}$

$2(0.371) = r$

$0.742 = \text{diameter}$

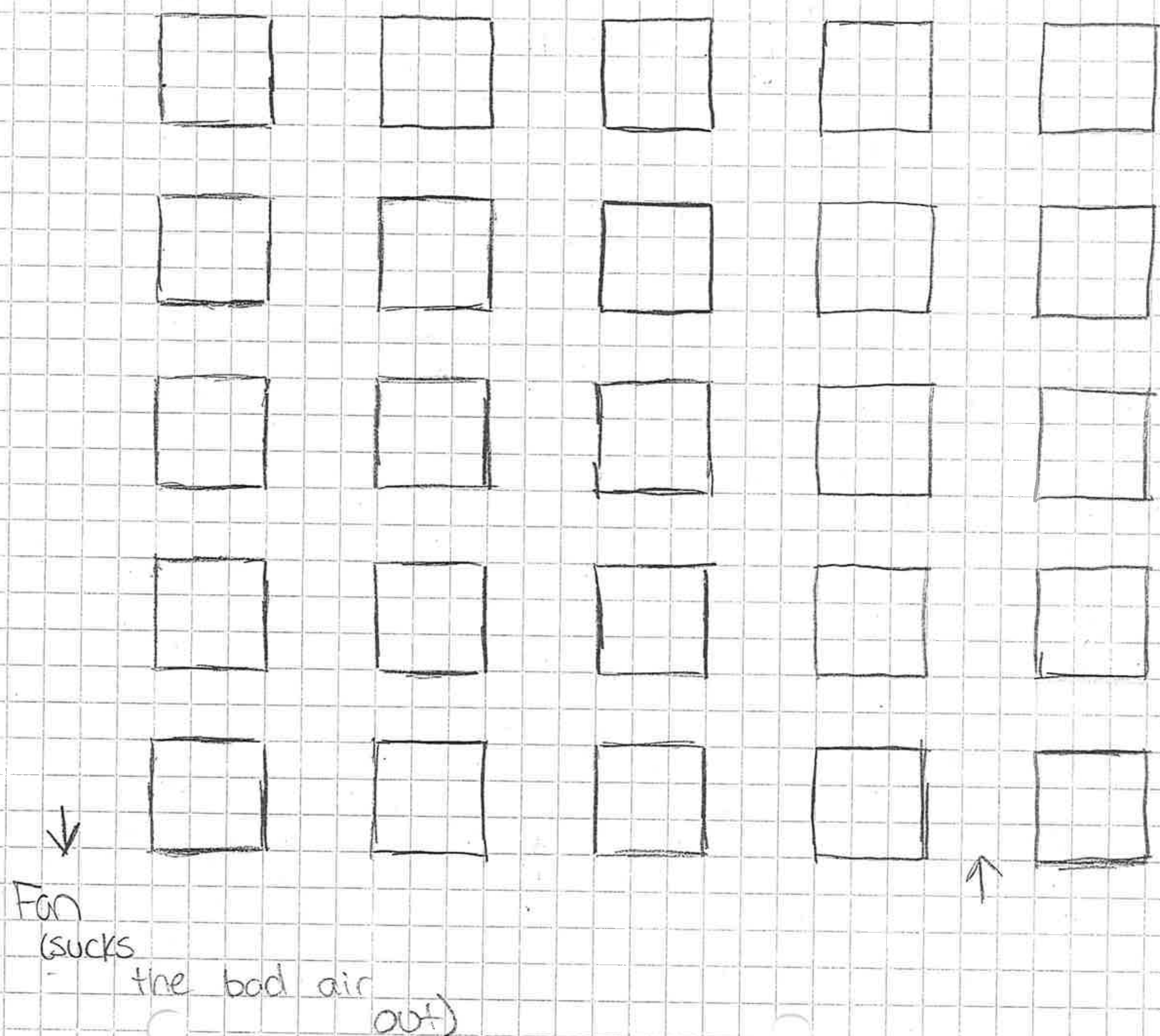
We will need 0.75 ($\frac{3}{4}$) in diameter roof bolts

Very Good!

Maximum Compressive Stress

$$\text{Stress}_{max} = \frac{(\text{weight of water})(\text{specific gravity of overburden})(\text{depth})}{(12\text{in}^2)}$$

$$\text{Stress}_{max} = \frac{(62.4)(2.5)(600)}{(12\text{in}^2)} = \frac{93,600}{144} = 650\text{ psi}$$


Fan
(sucks the bad air out)

Cross Section	Length
Split A = 6x18	1900 ft
Split B = 7x17	1750 ft
Split C = 7x13	1400 ft
Split D = 5x19	1300 ft

Split A

$$108\left[\frac{108}{(100\times10^{-10})(1900)(48)}\right] = 37,165$$

Split B

$$119\left[\frac{119}{(100\times10^{-10})(1750)(48)}\right] = 44,790$$

Split C

$$91\left[\frac{91}{(100\times10^{-10})(1400)(40)}\right] = 36,280$$

Split D

$$95\left[\frac{95}{(100\times10^{-10})(1300)(48)}\right] = 37,067$$

A = 37,165
B = 44,790
C = 36,280
D = 37,067
155,302

$A = \frac{37,165}{155,302} \times 180,000 = 43,075$ cfm

$B = \frac{44,790}{155,302} \times 180,000 = 51,913$ cfm

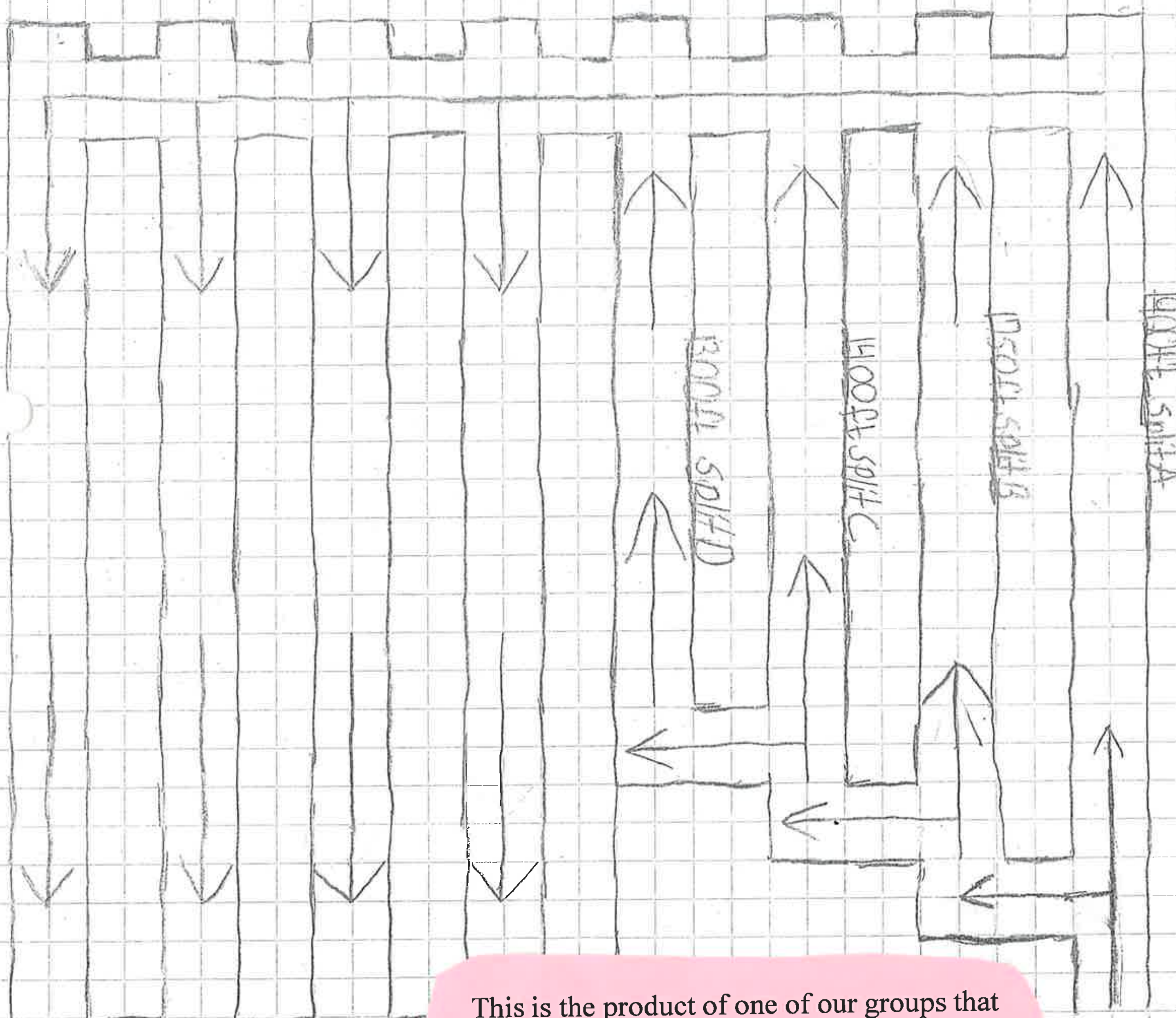
$C = \frac{36,280}{155,302} \times 180,000 = 42,050$ cfm

$D = \frac{37,067}{155,302} \times 180,000 = 42,962$ cfm

CSU #
03-05-19

Split A = 43,075 cfm
Split B = 51,913 cfm
Split C = 42,050 cfm
Split D = 42,962 cfm

12



This is the product of one of our groups that designed the ventilation schematic for our model mine. They are anticipating the section will grow with more entries and breaks. They determined the airflow and the air horse power for each entry.

K: intake: 60×10^{-10}
return: 80×10^{-10}

$H = RQ^2 = \frac{KSQ^2}{5.2A^3} = \frac{KLDQ^2}{5.2A^3}$

$HP = \frac{5.2HQ}{33,000}$

Split A

Intake: $\frac{60\times10^{-10}(48)(1900)(1000)(43,075)}{5.2(108)^3} = 0.155\text{ in}$

Return: $\frac{80\times10^{-10}(48)(1900)(43,075)}{5.2(108)^3} = 0.207\text{ in}$

H_T: $0.155+0.207 = 0.362\text{ in}$

$HP = \frac{5.2(0.362)(43075)}{33,000} = 2.46\text{ hp}$

Split B

Intake: $\frac{60\times10^{-10}(48)(1780)(51,913)^2}{5.2(119)^3} = 0.155\text{ in}$

Return: $\frac{80\times10^{-10}(48)(1750)(51,913)^2}{5.2(119)^3} = 0.207\text{ in}$

H_T: $0.155+0.207 = 0.362\text{ in}$

HP: $\frac{5.2(0.362)(51913)}{33,000} = 2.46\text{ hp}$

Split C

Intake: $\frac{60\times10^{-10}(40)(1400)(42,050)^2}{5.2(91)^3} = 0.152\text{ in}$

Return: $\frac{80\times10^{-10}(40)(1400)(42,050)^2}{5.2(91)^3} = 0.202\text{ in}$

H_T: $0.152+0.202 = 0.354\text{ in}$

HP: $\frac{5.2(0.354)(42,050)}{33,000} = 2.35\text{ hp}$

Split D

Intake: $\frac{60\times10^{-10}(48)([illegible])(42,962)^2}{5.2(95)^3} = 0.155\text{ in}$

Return: $\frac{80\times10^{-10}(48?)([illegible])(42,962)^2}{5.2(95)^3} = 0.207\text{ in}$

H_T: $0.155+0.207 = 0.362\text{ in}$

HP: $\frac{5.2(0.362)(42,962)}{33,000} = 2.45\text{ hp}$

CSU #
03-05-19

14

The Matewan Massacre

The gun battle that occurred in the early days of the coal-boom in Matewan, West Virginia had all the quintessential elements of a high-noon shootout. On one side, a pro-union mayor and sheriff; on the other, the henchman of the Baldwin-Felts Detective Agency. The Matewan Massacre, as it is referred to, was the result of ever present and long sustained tension between dastardly mine bosses and the coal miners whose backs the mine bosses' success was built on.

Within fifteen minutes of the standoff, ten people were dead. These included seven detectives, two coal miners, and, even the mayor of this small West Virginia coal mining town. After three months of violence, marshal law was declared, and federal troops had to intervene to assist in dissipating the angsty miners and detectives.

Then, as it is now, West Virginia is coal country, with coal mines being the primary source of employment. The miners worked towards unionization in order to better their working conditions. They often worked long, underpaid hours in unsafe, hazardous conditions. The bosses opposed the unionization of their laborers because it would mean the laborers had more rights as employees, thus making the bosses of the Stone Mountain Coal Company unable to use the men by overworking them in these hazardous conditions. It would give rights to the workers and instill rules the mines had to follow or face being shut down.

The shootout remains instilled in history as a reminder of what our ancestors, primarily in this coal-ruled region, had to face before achieving better working conditions. As labor historian Hoyt N. Wheeler writes, "Firing men for union activities, beating and arresting union organizers, increasing wages to stall the union's organizational drive, and a systematic campaign of terror produced an atmosphere in which violence was inevitable.

This is a product produced by two students in one of our history classes. It describes the Matewan Massacre and its impact on the community

The largest reason that the workers went on strike was to gain UMWA support to earn better working conditions. As the incredibly wealthy mine owners continued to become more powerful, the conditions persisted to worsen. Union organized strikes were ways that workers could come together and show a united front through collected force to better their chances of protecting their salaries. Workers' strength came from and only from collective action, this being the majority if not all workers of these mines coming together to show they would stand for these atrocious conditions no longer. In one successful protest, 400,000 UMWA went on strike nationwide in 1919, securing higher wages coupled with better working conditions. For pro-capitalists, it was merely a battle for profit and profit alone. For the laborers, it was a battle solely for human rights.

The two sides clashed in what has been dubbed "The Matewan Massacre", "The Battle of Matewan" along with many others. In response to a massive UMWA organizing effort in the area, local mining companies forced miners to sign yellow-dog contracts that bound them never to join a union. On May 19, Baldwin-Felts agents arrived in Matewan to evict miners and their families from Stone Mountain Coal Company housing. It was a normal day on the job for the agents; they provided law-enforcement contacts for railroad yards and other companies alike. The main job of these private detective agents being to suppress the unionizing of the laborers.

On this same day, miners came to collect their small pays and other items from the company store. The miners saw extremely rare support of the pro-union police chief and the mayor. According to historical accounts, the Baldwin-Felts agents attempted to arrest the police chief, Sid Hatfield, when he tried to intervene from the evictions takin place. The Mayor defended Hatfield, and was shot for doing so.

In response to the assassination, an army of 10,000 miners launched a full-fledged assault against the coal company and mine guards. When the conflict concluded, hundreds of miners were indicted for murder, and more than a dozen were charged with treason. Even worse, the UMWA experienced a significant decline in membership throughout the 1920s, and in 1924 the UMWA district that included Matewan lost its local autonomy because of the incident. As the years progressed, the union distanced itself even further from the Matewan massacre.

In conclusion, this shoe of sheer force and collective action through determined miners serve as a staple of progress for unionized labor and fair working conditions that we see in modern times.

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CSU #
03-05-19

18

Seeding of My Abandoned Mine Property Rubric

		Available Points	Points Awarded
1.)	Land track has correct ~~correct~~ dimensions, Labeled with accurate scale.	1.) 10 points	______
2.)	Statistical Estimation of the number of trees is reasonable, Mathematical calculations are correct.	2.) 10 points	______
3.)	Problem is high school appropriate and relavant to using abandoned surface mine property.	3.) 10 points	______

This is a copy of the rubric this group used to evaluate their problem involving the estimation of the number of hardwood trees on our property at a particular time interval

Here is a copy of the guided notes from one of my Precalculus students. This was from our class discussion on the use of exponentials and logarithms in estimating a transplanted elk population on our property.

CSU #
03-05-19

19

Date 2/6/19 Period 7th

Exponential Growth and Decay

Post Land Uses for Abandoned Surface Mines

Guided Notes(2)

Example 1: In 1997, The Rocky Mountain Elk Foundation released 200 Elk on abandoned surface mine property in Eastern Kentucky. By 2002 the population had expanded to approximately 600 elk.

A. Write an exponential growth function that models the data for 1997 through 2002. What is average annual growth rate for the elk herd?

(t, y)

$(0, 200)$ C

$(5, 600)$ K

$y = Ce^{Kt}$

$600 = 200e^{5K}$

$3 = e^{5K}$

$\ln 3 = \ln e^{5K}$

$\frac{\ln 3 = 5K}{5}$

$K \approx 0.2197$

growth rate of 21.97%

equation

$y = 200e^{0.2197t}$

B. Predict the number of elk in Eastern Kentucky 2005.

$y = 200e^{(.221)(8)}$

1162 elk

C. From 2005, how many years will take for the elk herd reach its maximum carrying capacity of 7400 elk?

$\frac{7400 = 1162e^{.22t}}{1162}$

$\frac{\ln\left(\frac{7400}{1162}\right) = .22t}{.22}$

t = 8.42 years

CSU #
03-05-19

20

	Points Avalible	Points Awarded
- Projects information is relevant to the title.	10	
- Projects information is relevant to mining coal in Kentucky.	20	
- The math in the project is correct, and relevant to the title and main idea.	25	
- Projects layout and design are in a organized, neat manner.	20	
- Projects paper matches the posters criteria	10	
- Project displays relevance to local problems	15	
	Total Points Avalible 100	Total Points Awarded

These students designed and solved a problem that allowed them to determine when the number of transplanted elk on our surface mine have reached their maximum carrying capacity. This is a copy of the student generated rubric used to evaluate their project..

21

CSU #
03-05-19

Mine Tours

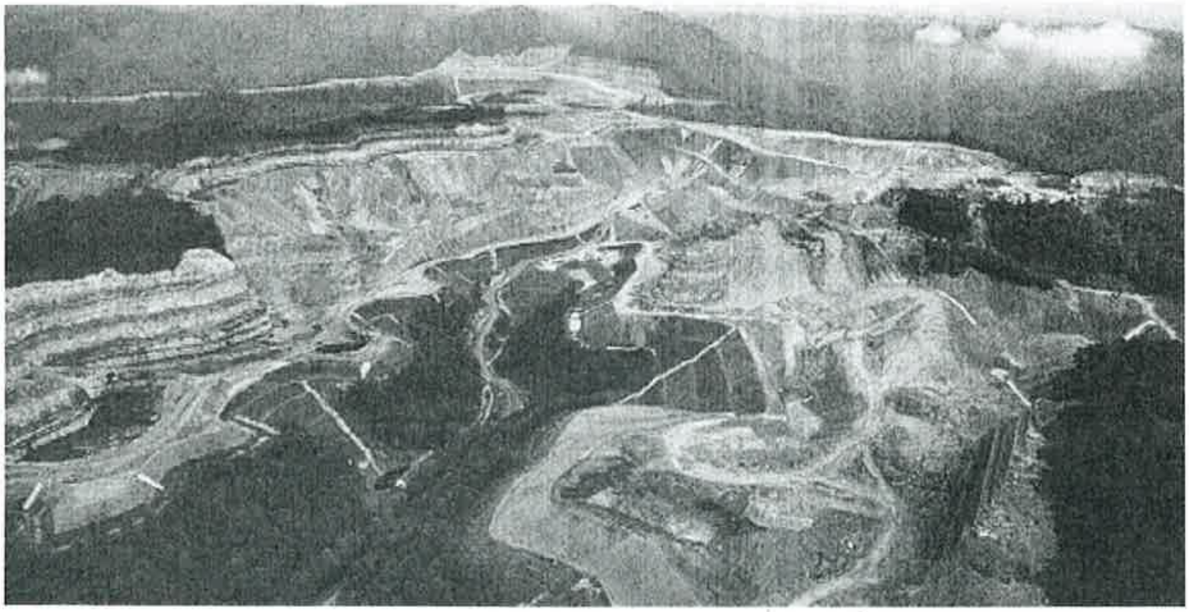
$1.00

Here is the sign that one of our students made showing that we are charging $1.00 for a tour of our model mine. We took this sign down after the first day.

CSU #
03-05-19

23

Surface Mining



This is a sample essay written by one of our senior English students.

Stop the War on Coal

The war on coal has been going on since about 2012 was when the coal mines started struggling to stay open due to stricter regulations and bankruptcy because of being fined by the EPA. Surface mining has been targeted by the EPA to stop its practices as one way to stop mining. I've done research and have found the benefits of surface mining and reason to continue using coal for coal powered electric plants. I have found websites and books about the benefits of surface mining and why it should be allowed. Along with surface mining these companies also offer good health benefits, retirement plans, and 401K plans (see National, for example). My purpose of this paper is to get people to stop the war on coal so miners aren't losing their job and don't have any other way to support their family. Some of these people turn to drugs when they don't have a job and any way to support their family so they think drugs is a way of ignoring their problems and not living a normal life and working. The goal of this paper is to persuade people that surface mining should be allowed due to the benefits of it; to show this I have divided the paper into three different sections.

History of Surface Mining

Surface mining has been around the Appalachian region for several years since about the mid 1900's (National). They were many towns across the Appalachian region that were little towns called coal camps where coal miners and their families lived in small little communities made up of small houses built by the coal companies. . A little town in Eastern Kentucky called Wayland, is one example of a coal town in the Appalachian region (Kentucky). Since most of the mines that were in towns like Wayland have shut down it has left these towns to waste and most of people living there have left to find new jobs and now these towns are pretty much ghost towns. These towns have been greatly impacted since the mines have shut down and there is just a few stores left in these towns. For example, in the town of Wayland there is only one grocery store, one gas station, and just a few locally owned restaurants.

The technology in the surface mining industry has greatly increased since surface mining first started in the mid 1900's. Technology has greatly advanced the progress of surface mining. Now in today's time we got bulldozers, loaders, dump trucks, excavators, high wall miners, swivel trucks, water trucks, graters, and drills. These are some examples of the equipment used on a surface mine job. To get certified to run these pieces of equipment miners must first pass their state required safety test and other test and then once hired they have to be trained to run the equipment before they are allowed to run these pieces of equipment themselves. Some people argue that surface mining is a dangerous job and that it shouldn't be allowed because of how dangerous it is. This is true, but when someone decides that they are going to work on a surface mines they know this before they even accept the job and take it anyway because they have to do something to provide for themselves and their family. They're other jobs that are just as dangerous as surface mining if not more dangerous.

About Surface Mining

There are three different methods of surface mining and each one is different in its own way. The three different methods of surface mining are mountaintop removal, contour mining, and area mining. The two main types of surface mining that are practiced the most are mountaintop removal and contour mining. In mountaintop removal it actually consist of all types of surface mining (mountaintop removal, contour, and area mining.) in the steep terrain of the central Appalachian coalfields (Mountaintop). Contour and area mining does not involve removing an entire mountaintop just to get to coal.

Mountaintop removal is the act of removing a mountaintop to expose coal seams, and disposing of the associated mining overburden in the adjacent valleys, "valley fills" (Mountaintop). Removal of overburden and interburden (rack above and between coal seams, respectively) during mountaintop mining results in generation of excess spoil must be placed in disposal sites adjacent to the mining pits in order to allow "for efficient and economical coal extraction" (Mountaintop). Typical locations for excess spoil disposal sites are valleys, also known as "head-of-hollows or uppermost (headwater) stream reaches" (Mountaintop). Mountaintop removal leaves three complexes: 1.) a highland or upland complex, compromising a mound sight with an extensive field nearby covered with hard, coarse vegetation. 2.) a valley fill, always adjacent to the highland or upland fill, marked by "groin damage" (Mary Hufford) in what was formerly a cove. 3.) a wetland drainage complex, compromising a "gathering pond" (Hufford) at the top the valley fill and a bottom pond. The top pond is clean, water caught at the bottom pond is treated with ammonia and manganese. According to Mary Hufford, "In mountaintop removal the undisturbed ground surrounds the perimeter of the actual mine site, and that fragments of forest run adjacent to the mine site along the valley fills". "Mountaintop removal mining has destroyed the Appalachian coal fields and has destroyed the land in Kentucky and West Virginia" says (Board). It is true that mountaintop removal is the most destructive type of mining practiced but, most mountaintop removal sites have been shut down due to stricter regulations and people still try to fight against mountaintop removal even though most of the jobs are shut down now.

According to McGowan "In 1977 the Federal Surface Mine Control and Reclamation Act was passed" to force mines to reclaim their mining site after they are done mining in the area. The EPA has started enforcing stricter regulations to force companies to follow through with reclamation efforts and make it safer to work in a piece of equipment. The EPA passed the Clean Air Act to reduce the amount of dust in a piece of equipment for miners to protect their lungs from the harmful dust particles. But due to an excess of regulations created by the EPA it has made it harder for mines to stay in business until recently when the power of the EPA was reduced to allow mines to go back to working again.

Benefits and Uses of Coal

Coal provides many job opportunities. Coal industry jobs can be filled by men and women interested in working. Coal industry careers include miners, engineers, geologists, electricians, and even emergency medical technicians (EMTs). Workers who work in this field are often paid well and must go through lots of safety and on-the-job training. Of the energy consumed in the United States in 2016, "14.7% of the energy consumed was coal" according to (National). All living plants store solar energy through a process known as photosynthesis. When plants die, the solar energy gets locked in the plants and the energy is locked into coal. Coal is used in many coal powered electric plants across Kentucky, West Virginia, Ohio, and Virginia. Coal is transported to these power plants and then burned and the energy is turned into electricity. Some people may argue that wind, solar, or hydroelectricity is a better, cleaner, and cheaper source of energy as to coal. While that may be true there is also factors that prevent these alternate sources of energy from being used in the Appalachian region. Solar power may not be used due to all the mountains and trees blocking the sunlight unless, these solar farms went in on top of reclaimed surface mines because it is mostly flat and there wouldn't be any trees or mountains to block the sunlight. The wind power cannot be used in the Appalachian region due to the mountains because there isn't enough power that would be produced by wind. There also are no major rivers that run straight through the Appalachians that can produce hydroelectricity except the Ohio River which would only benefit towns run right along with the river.

Conclusion

Taking into consideration of all the reasons I listed above is why surface mining should be allowed. These mines provides jobs for people in the Appalachian region and helps them provide for themselves and their families. This why the EPA needs to be limited from passing stuff that affects surface mines and causes them to shut down. The miners depend on these jobs so they can pay for their necessities. The land after a mine reclaims it can be used for many things such as such as industrial uses or even agriculture uses. The only renewable resource that could be used in the Appalachian region is solar energy and lots of trees and mountains would still have to be flattened to allow for the solar panels to get adequate sunlight to produce electricity.

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Extension Activities

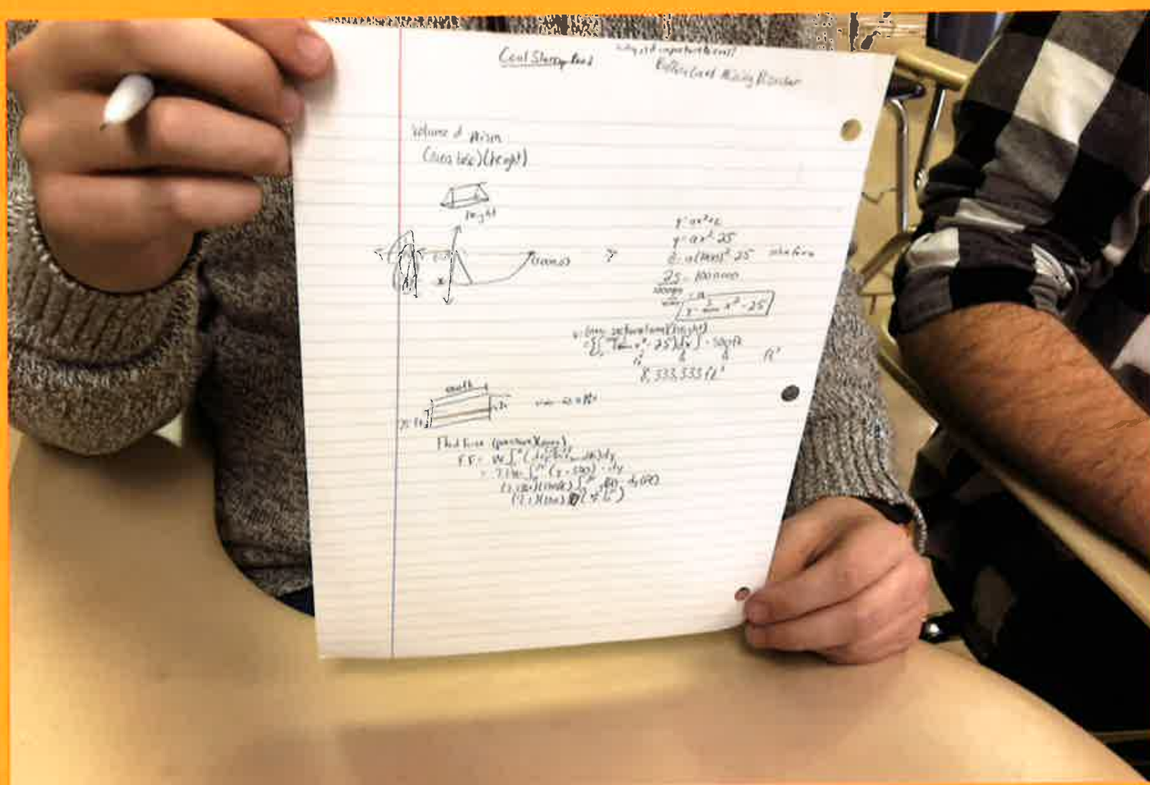
Going Beyond the Plan

More Rigorous
&
More Real

Two Student Work Samples From our
Pre-engineering Students

CSU #
03-05-19

4



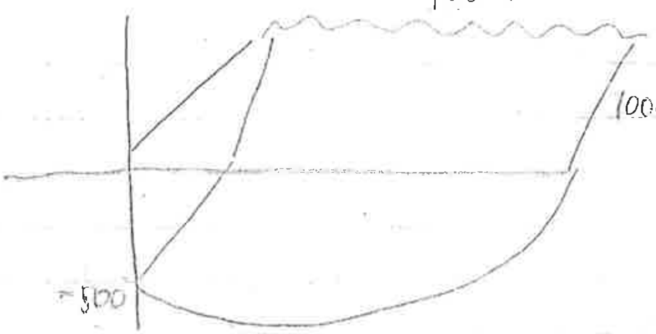
$f(x)g'(x) + g(x)f'(x)$

$(1/40000)(2x) +$ ______ $= 25$

Volume of a Slurry Pond on the mine property

4

CSU # 03-05-19



$y = ax^2 + c$

$y = a x^2 - 500$

$0 = a(1500)^2 - 500$

$\frac{500}{2250000} = \frac{a \, 2250000}{2250000}$

$\frac{1}{4{,}500} = a$

$y = \frac{1}{4{,}500}x^2 - 500$

Equation $y = \frac{1}{4500}x^2 - 500$

Volume = (area of base)(height)

$V = \left[\int_0^{1500} \left(\left(\frac{1}{4500}\right)(x^2) - 500\right) dx\right] \cdot (1000\,ft)$

ft · ft · ft

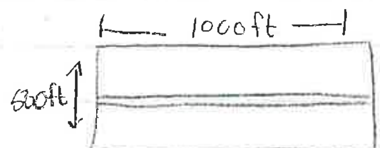
$50{,}000{,}000\ ft^3$ ← Volume of Slurry

F = (Pressure)(Area)

Fluid Force (FF) = $w\int_0^H$ (depth · width) d(depth)

weight of water (w)

$62.4\ lb/ft^3$



$FF = w\int_0^h (\text{depth} \cdot \text{width})\,dy$

$= 11.2\int_0^{500} (y \cdot 1000)\,dy$

$11.2\,(1000)\int_0^{500} (y\,ft \cdot dy\,ft)$

$11{,}200 \cdot \left(\frac{y^2}{2}\Big|_0^{500}\right)$

$\left[11{,}200 \cdot \frac{500^2}{2}\right] - \left[11{,}200 \cdot \frac{0^2}{2}\right]$

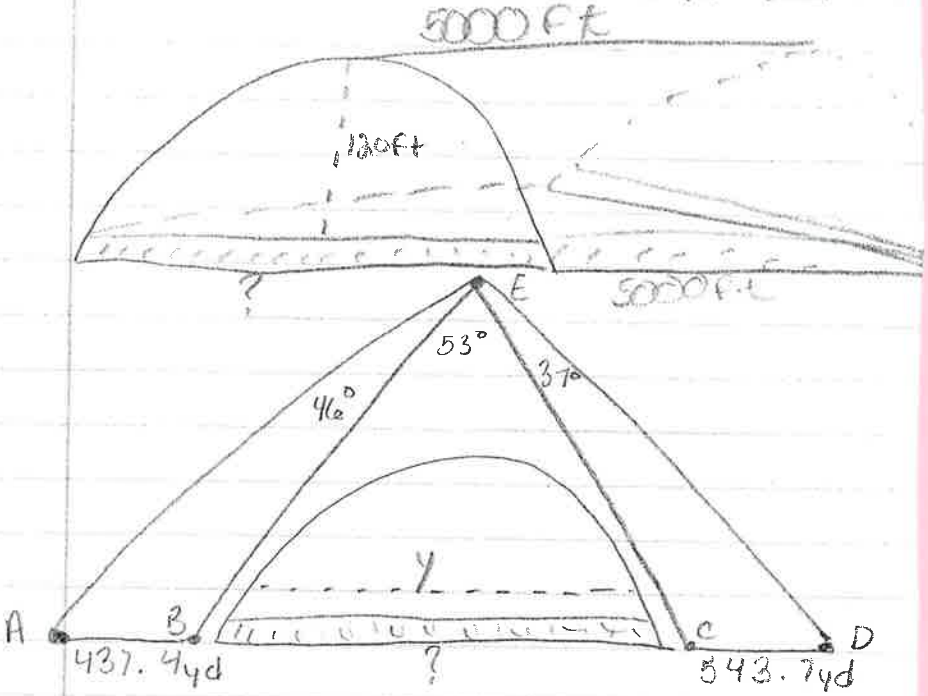
$1{,}400{,}000{,}000 - 0$

1,400,000,000 lbs ← Fluid Force

What if the coal slurry pond on our property contained an emergency overflow gate? A group in my AP Calculus class modeled the curvature of the bottom of the pond as a parabolic equation and used integral Calculus to determine the volume of the slurry in the pond. They determined the volume of water in the pond to be 50,000,000 ft_3. They also used Integral Calculus to find the Fluid Force due to the pressure of the coal slurry on the gate to be 1,400,000,000 lbs. A very real topic for today's coal mines.

CSU #
03-05-19

1



length of $\frac{EB}{EC} = \frac{EB}{EC}$

- $(\sin A)\frac{EB}{\sin A} = \frac{437.4(\sin A)}{\sin 46^\circ} = \frac{437.4\sin A}{\sin 46^\circ}$

  $EB = \frac{437.4\sin A}{\sin 46^\circ}$

- $(\sin A)\frac{EC}{\sin A} = \frac{(437.4+4)(\sin A)}{\sin 83^\circ} = \frac{(437.4+4)\sin A}{\sin 83^\circ}$

  $EC = \frac{(437.4+4)\sin A}{\sin 83}$

- $\frac{EB}{EC} = \frac{\frac{437.4\sin A}{\sin 46^\circ}}{\frac{(437.4+4)\sin A}{\sin 83^\circ}}$

What if the coal seam containing our coal mine is a drift mine going back into the side of a mountain? This group had to calculate the volume of coal in our coal seam. In order to make the problem more rigorous they used the Law of Sines and The Quadratic Formula to determine the width of the coal seam. They then modeled the curvature of the mountain with a parabolic curve and used Integral Calculus to calculate the volume of the overburden and the volume of the coal on the property. Last they extended the problem even more by determining the Stripping Ratio. Their ratio was 13:1. Excellent extension and relevant to our mine!

- $\frac{437.4 \sin A}{\sin 46^\circ} \cdot \frac{\sin 83^\circ}{(437.4+y)\sin A}$

- $\frac{437.4(\sin 83^\circ)}{(437.4+y)\sin 46^\circ} = \frac{EB}{EC}$

- $(\sin D)\frac{EC}{\sin D} = \frac{543.7}{\sin 53^\circ}(\sin D) = \frac{543.7 \sin D}{\sin 53^\circ}$

  $EC = \frac{543.7 \sin D}{\sin 53^\circ}$

- $(\sin D)\frac{EB}{\sin D} = \frac{y+543.7}{\sin 90^\circ}(\sin D) = \frac{(y+543.7)\sin D}{\sin 90^\circ}$

  $EB = \frac{(y+543.7)\sin D}{\sin 90^\circ}$

- $\frac{EB}{EC} = \frac{\frac{(y+543.7)\sin D}{\sin 90^\circ}}{\frac{543.7 \sin D}{\sin 53^\circ}}$

- $\frac{(y+543.7)\sin D}{\sin 90^\circ} \cdot \frac{\sin 53^\circ}{543.7 \sin D}$

  $\frac{EB}{EC} = \frac{(y+543.7)\sin 53^\circ}{543.7(\sin 90^\circ)}$

Cross multiply

- $\frac{EB}{EC} = \frac{437.4(\sin 83°)}{(437.4+y)\sin 46°} = \frac{(y+543.7)\sin 53°}{543.7(\sin 90°)}$

- $(437.4)(\sin 83)(543.7)(\sin 90°) = \frac{(\sin 46)(437.4+y)(\sin 53)(y+543.7)}{(\sin 46)\ (\sin 53)}$

- $\frac{(437.4)(\sin 83°)(543.7)(\sin 90°)}{(\sin 46°)(\sin 53)} = 410871.59$

- $410871.59 = (y+437.4)(y+543.7)$

  $410871.59 = y^2 + 981.1y + 237814.38$

  $-410871.59 \qquad -410871.59$

  $0 = y^2 + 981.1y - 173057.21$

- Quadratic Formula

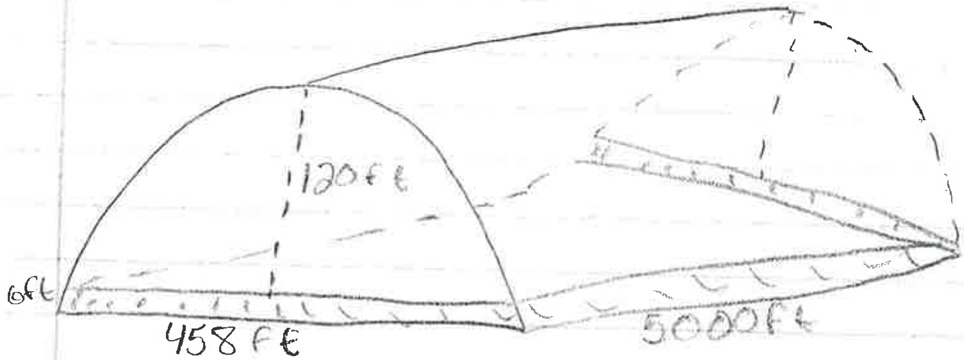
$-(981.1) \sqrt{(981.1)^2 - 4(1)(-173057.21)} / 2(1)$

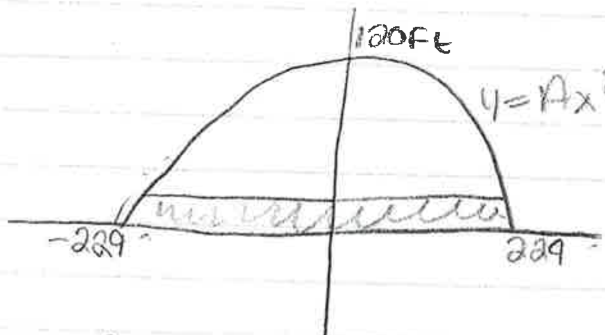
$\frac{-981.1 \pm 1286.38}{2}$

$y = \cancel{-1133.74}$ can't be negative

$y = 152.64$

length is 152.64 yds → 457.92 ft





- $y = Ax^2 + C$

  $y = Ax^2 + 120$

  $0 = A(229)^2 + 120$

  $\frac{-120}{229^2} = \frac{A(229)^2}{229^2}$

  $-0.002 = A$

- $y = -0.002x^2 + 120$

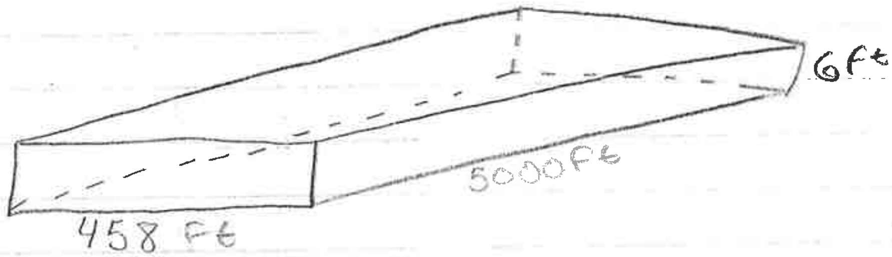
Cross Sectional area:

- $\left[\int_{-229}^{229} (y = -0.002x^2 + 120)\,dx\right](5000\text{ ft})$

  $(38948\text{ft}^2)(5000\text{ ft})$

  $194{,}740{,}000\text{ ft}^3$ ← Volume of the overburden + Coal

• Coal scene:



• $V = LWH$

$V = (458)(5000)(6)$

$V = 13,740,000 \text{ ft}^3$ ← Volume of coal

• Stripping burden:

$$\frac{\text{volume overburden}}{\text{volume coal}}$$

$194,740,000 - 13,740,000 = 181,000,000$

$$\frac{181,000,000}{13,740,000} = \frac{13.17}{1}$$ ← stripping ratio

Excellent

CAUTION

Left over Pictures from our
Coal Study Unit

You should view these only if you like seeing
pictures of kids having fun learning about coal

CSU #
03-05-19

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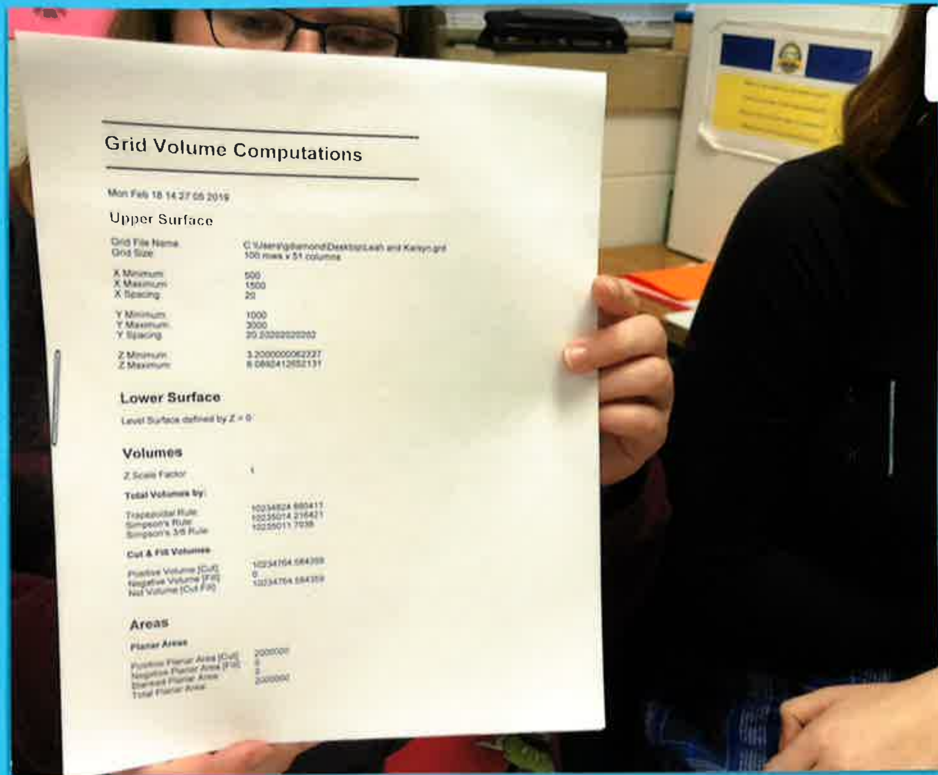
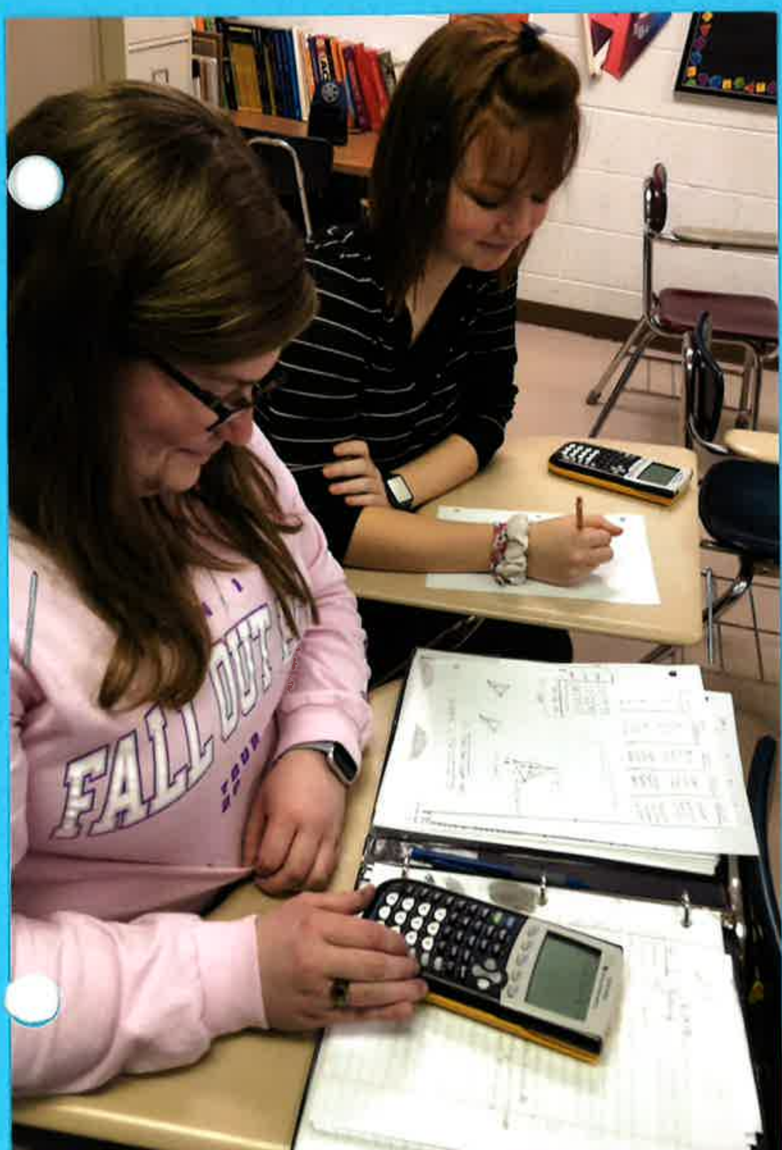
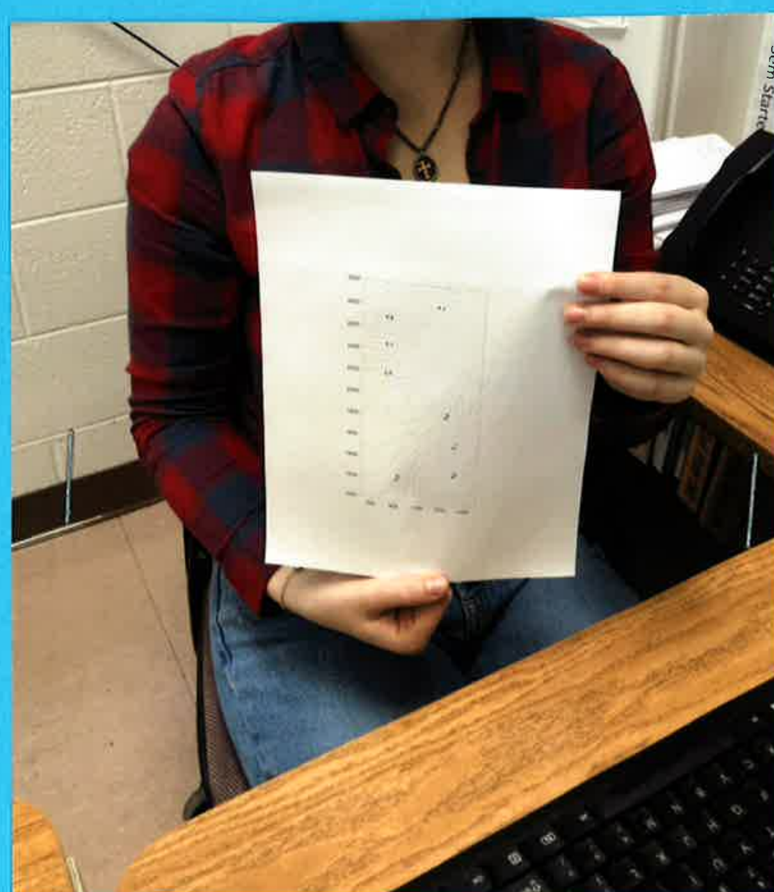

Grid Volume Computations
Upper Surface
X Minimum 500
X Maximum 1500
X Spacing 20
Y Minimum 1000
Y Maximum 3000
Lower Surface
Volumes
Areas


FALL OUT



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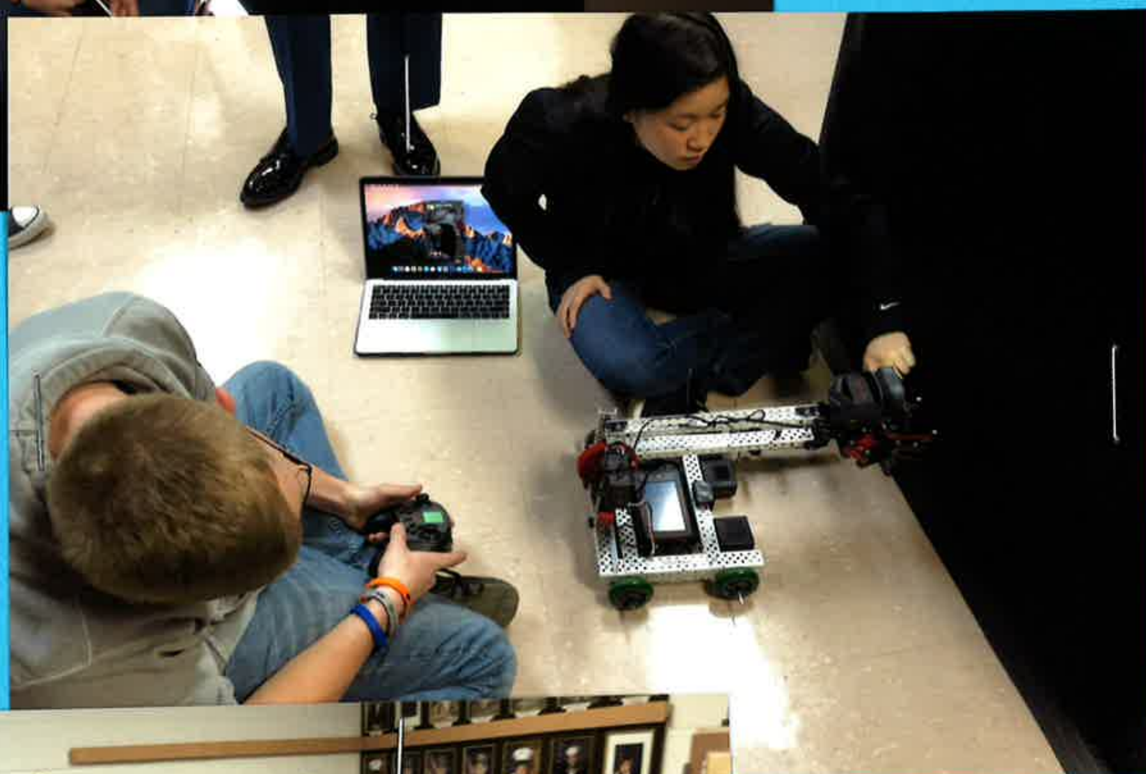

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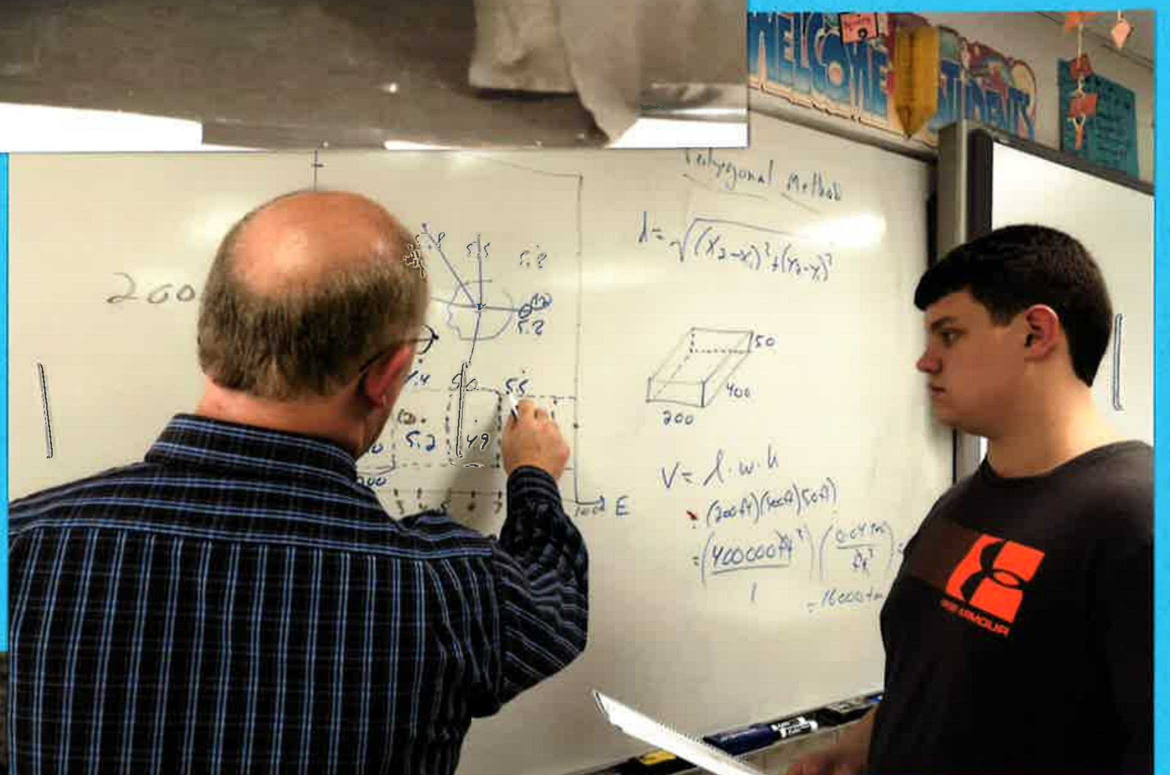

Thanks for Looking at our Unit