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# The Utilization of the Coal and Land Resources of One Piece of Property in Eastern Kentucky

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## I. INTRODUCTION

Once again, I turned to my AP Calculus students to help me and the other participating teachers pick a topic for this year's CEDAR Coal Study Unit. Several students mentioned that this past year they had seen more coal trucks on the roadways in our county hauling coal. One student mentioned that "coal mining was back!" and that not even President Hillary(no one believed that Trump could win) could stop coal from rebounding. My students discussed pros and cons of several different coal topics. About half the class wanted to investigate surface mining and other half wanted to study underground coal mining. I tried to steer the class towards future land uses of abandoned surface mine property. We finally decided on a topic that was broad enough to satisfy everyone. The focus of our unit would be "The Utilization of the Coal and Land Resources of One Piece of Property in Eastern Kentucky" This topic would allow our students to learn how to maximize the coal resources on the property and investigate future land uses of any level property after surface mining has been completed. The topic was broad enough that we could include students from every academic area at our school and involve the participation of as many students as possible.

Each year I try to get my math students to understand that they will actually use mathematics in their everyday life after they graduate from high school and I emphasize that students who can apply mathematics usually get the best paying jobs. Math is even important in coal mining. With this in mind, I felt it was important that our unit should contain several elements. First, the unit should be broad enough to include all academic departments at the school and involve the participation of as many students as possible. Second, the unit should emphasis contextual learning. Students that are engaged in hands-on learning activities will be much more likely to retain what they have learned. Third, the unit should challenge students to solve real world problems encountered in coal mining. They should have to think critically, use problem-solving skills and be engaged at the highest levels of Blooms Taxonomy. Fourth, the unit should address the new core content standards in each academic area and should satisfy specific elements within the Program of Studies for each course.

The students in each content area were assigned to groups of 3 or 4 students and asked to investigate at least one specific element involving the utilization of the coal and land resources of our property. This could involve mining the coal using underground mining methods, removing the coal near the surface, or post land uses of the property. Our Pre-engineering students got the unit started by mapping the land track and by generating a 2-D or 3-D picture of any coal seams on the property. They used vector mechanics to determine whether a coal slurry pond dam on the property was safe by calculating the "Safety Factor" for the dam. They also investigated uses for land after surface and underground mining of the property had been exhausted. This was a great unit…

The unit addressed the following KACS standards:

1. **–CED** Create equations that describe numbers or relationships
2. **G-GMD** Explain volume formulas and use them to solve problems
3. Understand and evaluate random processes underlying statistical experiments
4. **N-VM** 5 (+) Multiply a vector by a scalar, Compute the magnitude of a scalar multiple.
5. Visualize relationships between two-dimensional and three-dimensional objects
6. **G-MG** Modeling with Geometry, Apply geometric concepts in modeling situations
7. **G-GPE** Use coordinates to compute perimeters of polygons and areas of triangles and rectangles, e.g., using the distance formula
8. **G-GMD** 3. Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems
9. **G-MG** Apply geometric methods to solve design problems
10. **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
11. **A-CED** Create equations that describe numbers or relationships

12 **G-GPE** 7. Use coordinates to compute perimeters of polygons and areas of triangles and rectangles

13 G-GMD Explain volume formulas and use them to solve problems

14 Visualize relationships between two-dimensional and three-dimensional objects

15. **G-MG** Apply geometric concepts in modeling situations
16. **2.4** Students use the concept of scale and scientific models to explain the organization and functioning of living and nonliving things and predict other characteristics that might be observed
17. **2.19** • human actions modify the physical environment and, in turn, the physical environment limits or promotes human activities.
18. **2.30** Students evaluate consumer products and services and make effective consumer Decisions
19. **1.14** Students make sense of ideas and communicate ideas with music
20. **2.22** Students create works of art and make presentations to convey a point of view.
22. **FLE** Construct and compare linear, quadratic, and exponential models and solve problems

**Here is a list of the "I Can" statements that were addressed in our unit:**

1. I can use the polygonal method to accurately estimate the volume of coal in the coal seam and determine its current market value.
2. I can use core drilling data and geostatistical techniques of Inverse Distance and/or Delauney Triangulation, to predict the height of the coal seam at a pond located on the property.
3. I can use techniques of Vector Algebra to determine if a dam for a slurry pond can be located on the property without causing the underlying rock strata to collapse.
4. I can use the Surfer 8 computer software to estimate the volume of coal in the coal mine.
5. I can use a computer ventilation software program ( VnetPC 2000, MineVent, ect. ) to design a ventilation schematic of the coal mine.
6. I can use Surfer 8 computer software to draw two different 2-dimensional and 3-dimensional pictures of the coal seam.
7. I can use core drilling data and Surfer 8 computer software to predict the height of the coal seam at a pond located on the property.
8. I can use algebraic techniques to estimate the maximum pillar size at our mine if the mine incorporates square pillars and maximum recovery is desired (50%).
9. I can use algebraic techniques to determine the minimum laboratory compressive strength of the coal at the mine in order for stability to be achieved.
10. I can use algebraic techniques to determine the safety factor for compressive failure of the mine pillars by utilizing the Holland-Gaddy relationship.
11. I can use algebraic and geometrical techniques to calculate the diameter of the roof bolts needed at the mine.
12. I can use algebraic and geometrical techniques to calculate the distribution of air according to natural splitting among four parallel splits.
13. I can determine the impact of pressure change on the on the ventilation system of the underground coal mine.
14. I can analyze the ash, moisture, BTU, and sulfur content of the coal that is mined at the property.
15. I can research the history of coal mining in Eastern Kentucky.
16. I can bake a cake or pastry that models the coal seam and the surrounding rock strata.
17. I can compose the music lyrics of a song that has coal as a central theme.
18. I can construct a 2-dimensional or 3-dimensional work of art that is about coal mining.
19. I can use statistical methods to estimate the number of transplanted hardwood trees that are still growing on the property at the end of a specified period of time.
20. I can use exponentials to estimate the $10^{th}$ and $20^{th}$ year growth rate of an elk population that that was transplanted to the property after all surface mining was completed.
21. I can use logarithms to estimate the number of years until the transplanted elk herd has reached its maximum carrying capacity.

**There are 10 essential questions that were utilized in this unit:**

1. If underground mining methods are used to access a coal seam on the property, what types of preplanning would be implemented in the design of the underground mine?
2. How can technology be used in the design and operation of the underground coal mine that is located on the property?
3. What can be done to prevent roof falls in the underground coal mine that is located on the property?
4. How can we ventilate our underground coal mine so that the mine can be operated safely?
5. How can we determine the quality of the coal that is mined at our coal mine?
6. Why is it important to study the history of coal mining in our area?
7. How can I express my feelings about coal by creating a 3-deminsional model of our coal seam and the surrounding rock strata?
8. How can I express how I feel about coal mining in Eastern Ky though music and song?
9. How can I express my feelings about coal mining through visual art?
10. If a large portion of the property is now relatively level due to recent surface mining activity, what are some potential uses for this land that could improve the quality of life for people living in the surrounding area?

## II. ACTIVITIES AND GOALS

The students that participated in this unit practiced cooperative learning and peer teaching skills by collaborating with and working with other students in small groups. They used critical thinking and problem solving skills to make decisions concerning design and operation of an underground coalmine 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 student participated and became part of a total immersion learning activity. The following is a brief description of the learning activities implemented in each subject area at our school.

### A. Mathematics

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 coal seams. They also placed a small pond 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 the inverse distance to a power, triangulation, and Delauney Triangulation. We also used ordinary kriging techniques to calculate the volume of the coal and predict the coal seam height at the pond. This was accomplished using Surfer 8 Simulation software. Each group used the quadratic formula to calculate the minimum size of the remaining coal pillars and determined the minimum size roof bolt needed to adequately 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 Holand-Gaddy safety factor for failure of the mine pillar.

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.

**B. Science**

Chemistry students performed coal analysis on the coal found at our mine site. This included tests for ash content, moisture, BTU, and calorific values.

Physics students investigated the change in the frictional pressure drop (Pa) along the air pathway of the mine as a function of the airflow ($ft^3$/min). They focused on two variables associated with underground coalmine ventilation.

1. How does the "roughness or coarseness" of the sides of the mine impact the frictional pressure drop along the air pathway?

These ventilation experiments were performed in the math department hallway using three 40 foot long wind tunnels made with a fan, smooth PVC pipe to simulate a mine whose air pathway is straight with smooth sides (this was the control), corrugated sewage pipe to simulate a mine with rough sides.

**C. Pre-Engineering**

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 the concrete dam of a coal slurry pond located on the property was safe by determining its safety factor. They also investigated how to best utilize the property after any surface mining is completed. They estimated the number of trees on the property 5 years after reseeding the property to restore the original hardwood forest. They also decided 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.

**D. English**

Students in our English classes expressed how they felt about coal mining by writing either a short story or poem about coal mining.

**E. Social Studies**

Students enrolled in US government classes conducted research on the history of coal mining in Kentucky.

**F. Technology**

Technology was used in every academic area as a powerful tool to solve complex problems and make important decisions concerning the utilization of our property. The application of technology in this unit was both challenging and relevant to the problems faced in underground coal mining. A list of some important types of technology used in our unit would include: Computers, Surfer 8 Simulation Software, calculators, VCR, TV camcorders, sound mixers, digital camera, mapmaking hardware, and the internet.

**G. Art**

Art department students produced 2-dimensional and 3-dimensional works of art with coal as the central theme.

**H. Music**

Music students composed and recorded songs about various aspects of coal mining and its impact on the people of Eastern Kentucky.

**I. Food Services**

Students in the culinary skills classes made a dessert or pastry that illustrated a 3-dimenaional cut-a-way view of the coal seam and the surrounding rock strata. The then shared these with other students and faculty within the school community.

**III. SUMMARY**

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 the miner and his family. These jobs also support local businesses, schools, and help support 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. The Big Sandy Area Airport, and the Sportsplex in Knott County is two examples of this type of development. Even abandoned mine property in rural areas can be valuable by providing wildlife habitat for small and large game animals. The Elk herd that we see in Eastern Ky was originally transplanted onto abandoned surface mine property.

The participating teachers and the students believe that this unit was one of our best CEDAR units. 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. It met or exceeded all four criteria mentioned in the introduction. It involved the active participation of eighteen teachers, one administrator, and approximately 392 students. The students learned in a contextual manner using hands on activities that helped them retain what they learned, thus becoming active learners in a coal related integration project involving all academic areas. Students participating in the unit were engaged at the highest levels of Blooms Taxonomy: analysis, synthesis, and evaluation. They were asked to judge the success of the entire unit and make recommendations for improvements.

At the completion of the unit, the students were asked to critique the unit. They were asked to make suggestions on how to improve the unit and to list what they liked about the unit. The responses from the students were very positive. Of course, most students would rather do hands-on, engaging activities rather than traditional work out of a textbook. The feedback from the student evaluations will become a valuable tool that the teachers can use to improve the unit if it is taught again.

The participating teachers and the unit coordinator evaluated the effectiveness of the unit based upon the degree to which the unit met or exceeded the High school core content for each class, covered the program of studies, and met components of our schools improvement plan. It was apparent to all participants that this unit met all the expectations that we had originally set for the unit.

Participating teachers in each department evaluated their students using one or all of the following methods.

I. Formative Evaluation

a. Daily oral questions of students by the teacher
b. Oral presentations
c. Investigation and group product evaluations
d. Open-response questions
e. Quizzes

2. Summative Evaluation
   a. Culminating activity
   b. Unit examinations

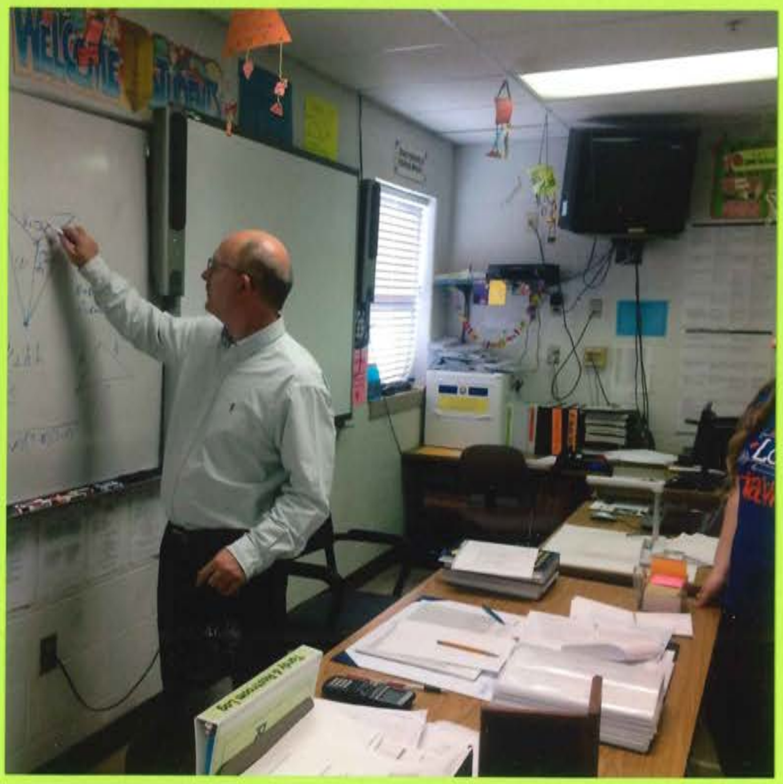
The activities taught in this unit were designed to allow students the opportunity to learn in the type of multiple intelligence and learning style that best suited their needs. These styles included linguistic, logical mathematical, spatial, musical, bodily-kinesthetic, interpersonal, and intrapersonal. 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.

The responses of the students and teachers that participated in this unit have been overwhelmingly favorable. The unit allowed each teacher to teach content that they usually teach but in a different way. The students involved in the unit believe that their understanding of underground coalmine design and preplanning has been enhanced. They indicated that they especially liked the hands-on nature of the activities and enjoyed participating in the cooperative learning / peer teaching aspects of the unit.

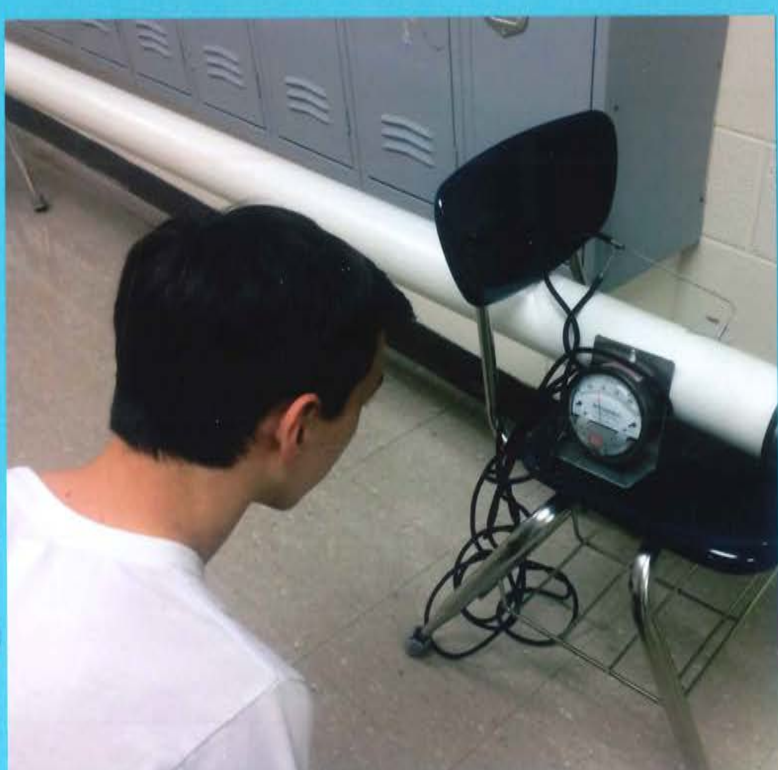
In conclusion, our coal study unit must be considered a total success because the goal set for the unit was achieved. The ten essential questions were either met or exceeded and the four criteria set forth in the introduction were all realized. Student learning was enhanced. Their critical thinking and problem solving skills have been improved. Most importantly, these students will take with them a greater understanding of underground coalmine design and preplanning, an appreciation of the difficult job performed by coal miners, and a realization of how important underground coal mining is to Pike County, the state of Kentucky, and the United States of America.

03-03-17

# Pictures



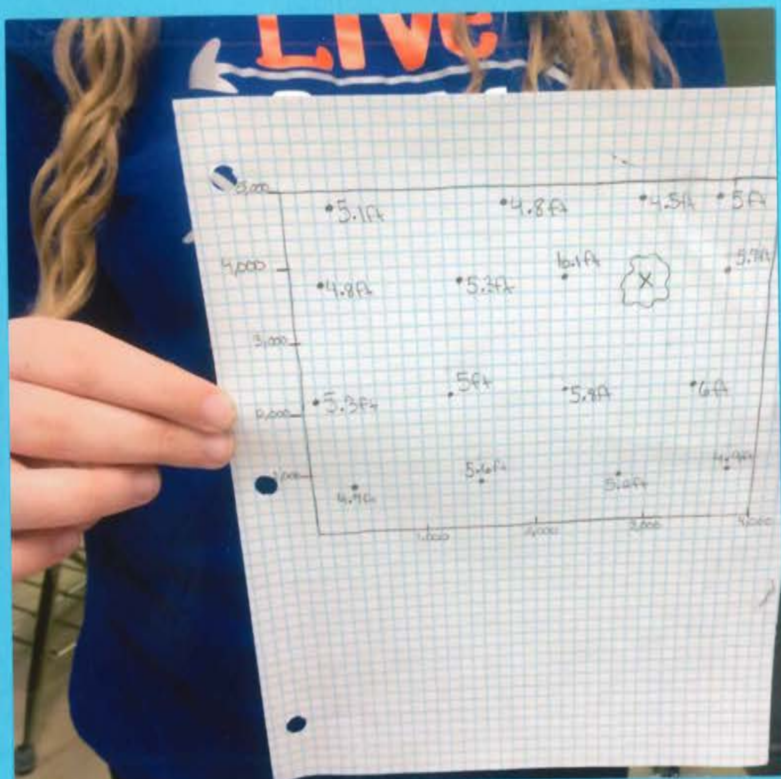
# Science



I can analyze the ash, moisture, BTU, and sulfur content of the coal that is mined at the underground coal mine.

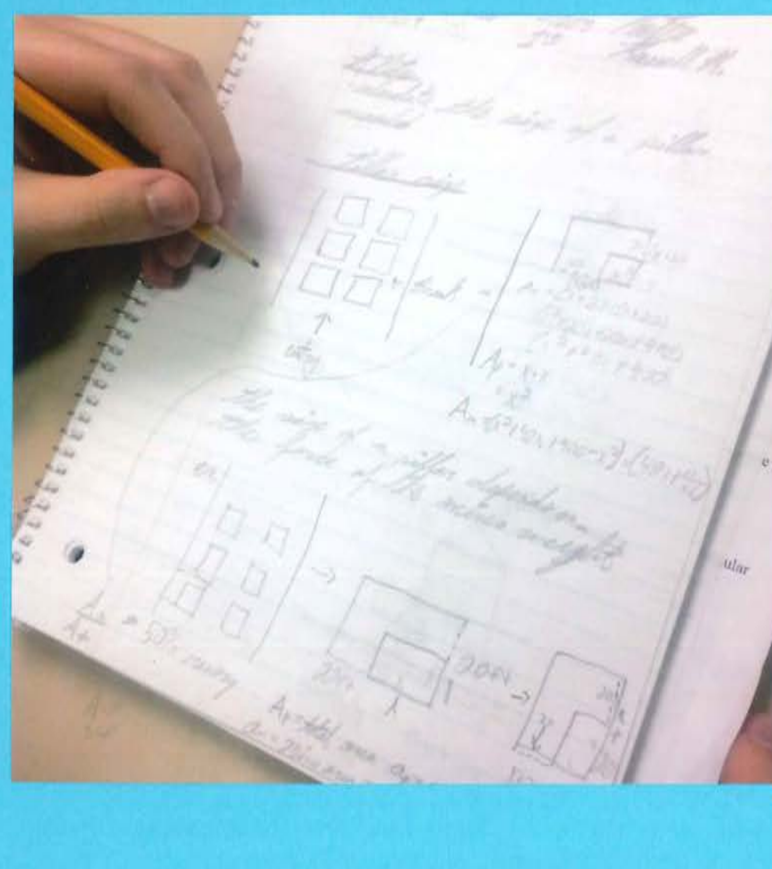
I can determine the impact of pressure change on the on the ventilation system of the underground coal mine.

# Mathematics

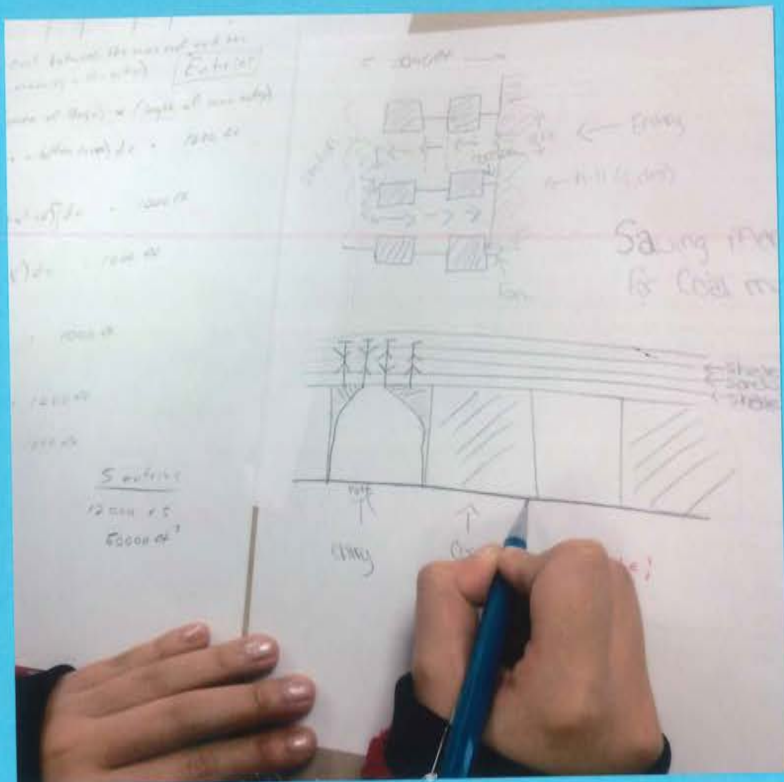



I can use the polygonal method to accurately estimate the volume of coal in the coal seam and determine its current market value.

I can use algebraic techniques to estimate the maximum pillar size at our mine if the mine incorporates square pillars and maximum recovery is desired (50%).



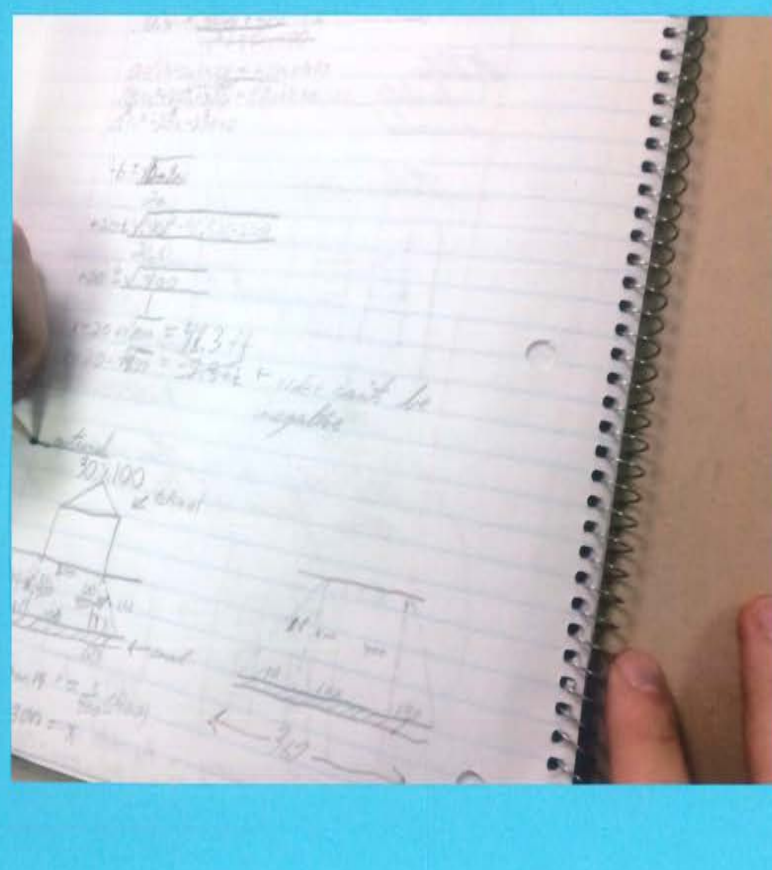
I can use algebraic techniques to determine the safety factor for compressive failure of the mine pillars by utilizing the Holland-Gaddy relationship.

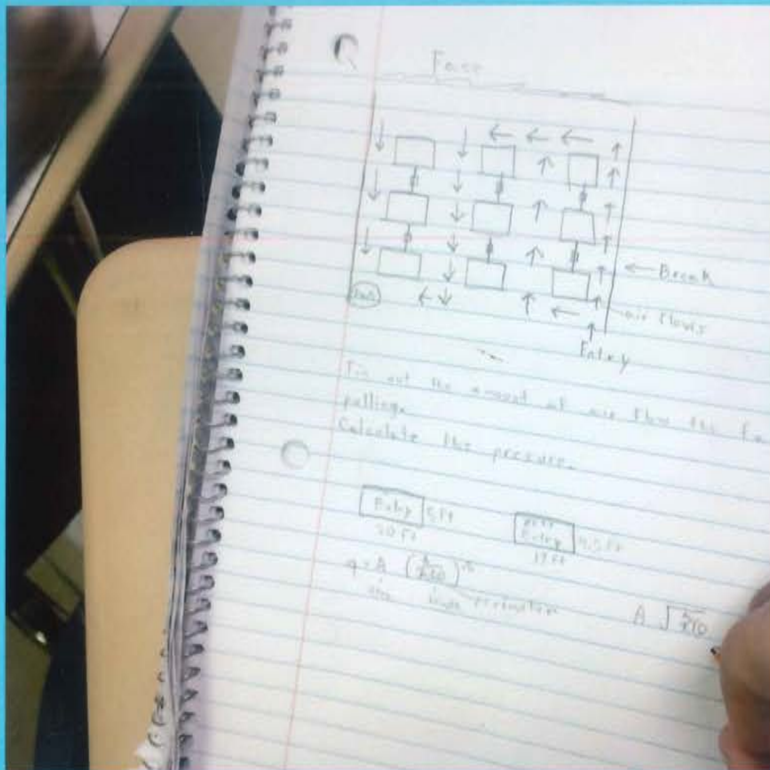


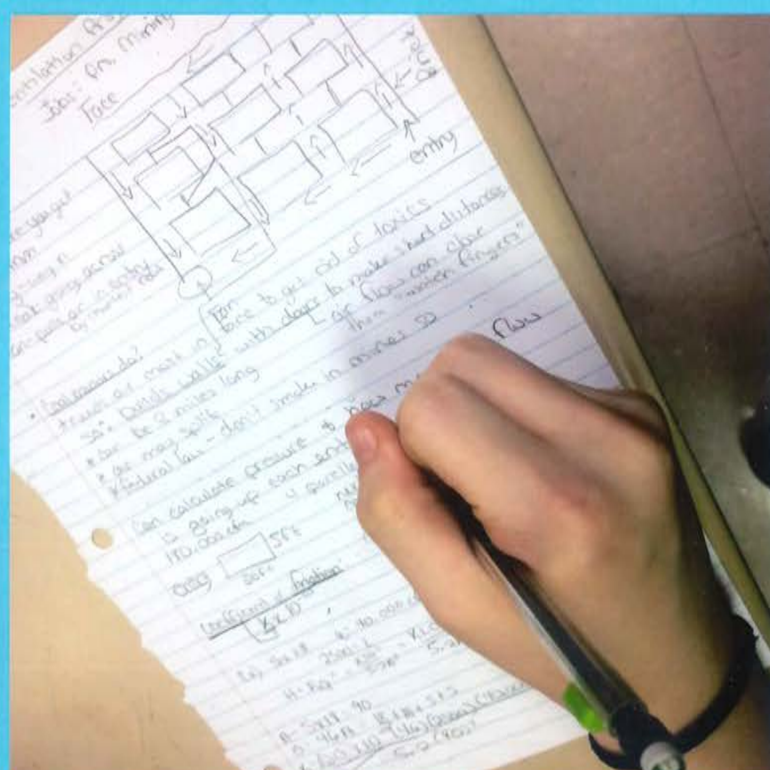
I can use algebraic techniques to determine the minimum laboratory compressive strength of the coal at the mine in order for stability to be achieved.

I can use algebraic and geometrical techniques to calculate the diameter of the roof bolts needed at the mine.

. I can use core drilling data and geostatistical techniques of Inverse Distance and/or Delauney Triangulation, to predict the height of the coal seam at a pond located on the property.

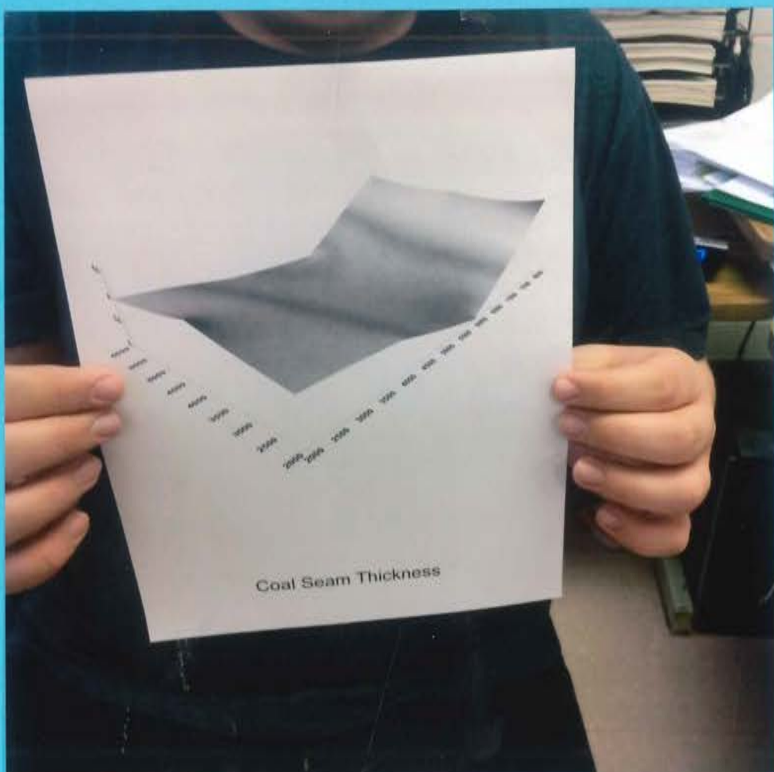





I can use algebraic and geometrical techniques to calculate the distribution of air according to natural splitting among four parallel splits.

# Pre-engineering

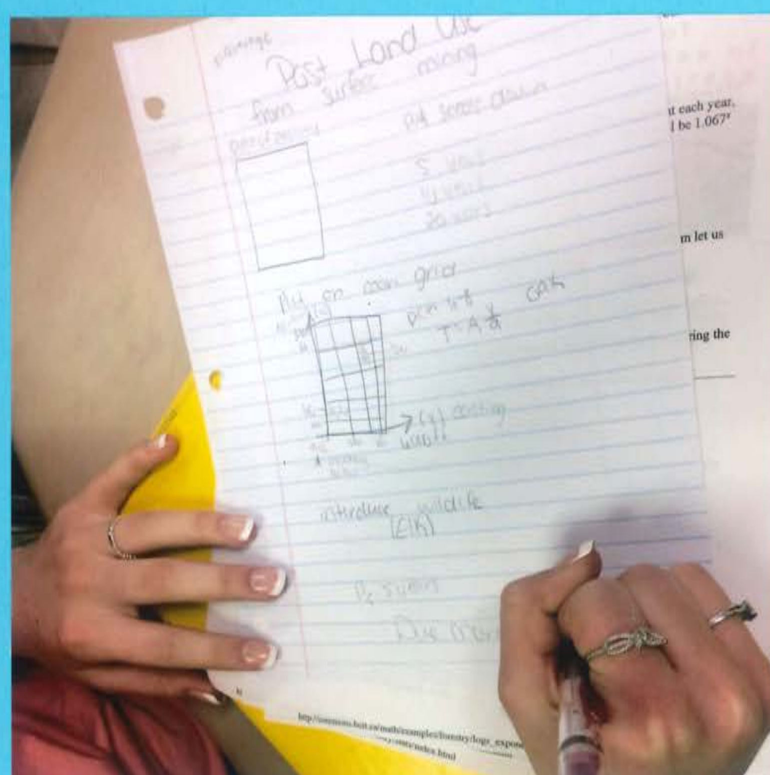



. I can use Surfer 8 computer software to draw two different 2-dimensional and 3-dimensional pictures of the coal seam.

I can use core drilling data and Surfer 8 computer software to predict the height of the coal seam at a pond located on the property.

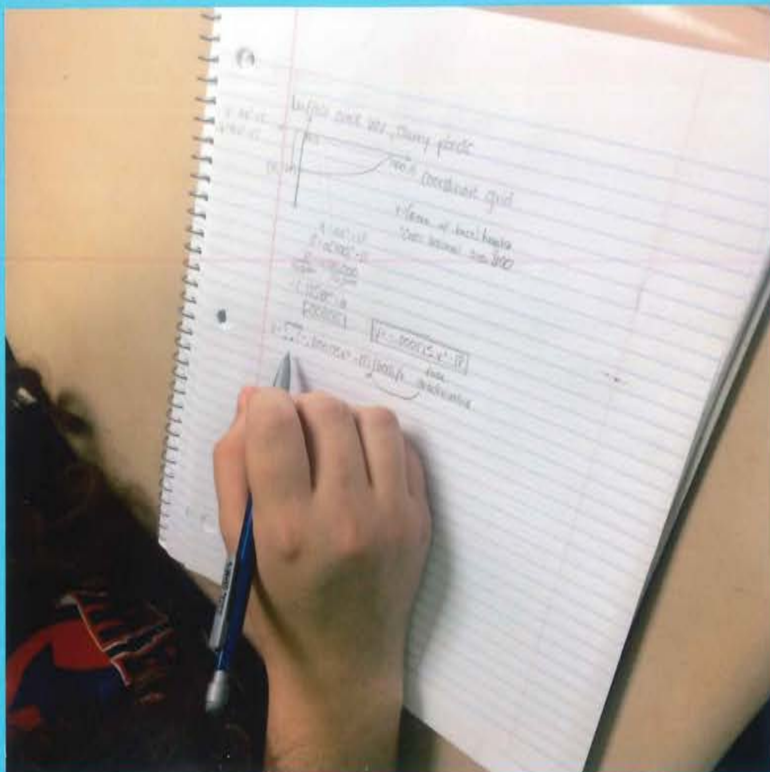
I can use the Surfer 8 computer software to estimate the volume of coal in the coal mine.

I can use logarithms to estimate the number of years until the transplanted elk herd has reached its maximum carrying capacity.

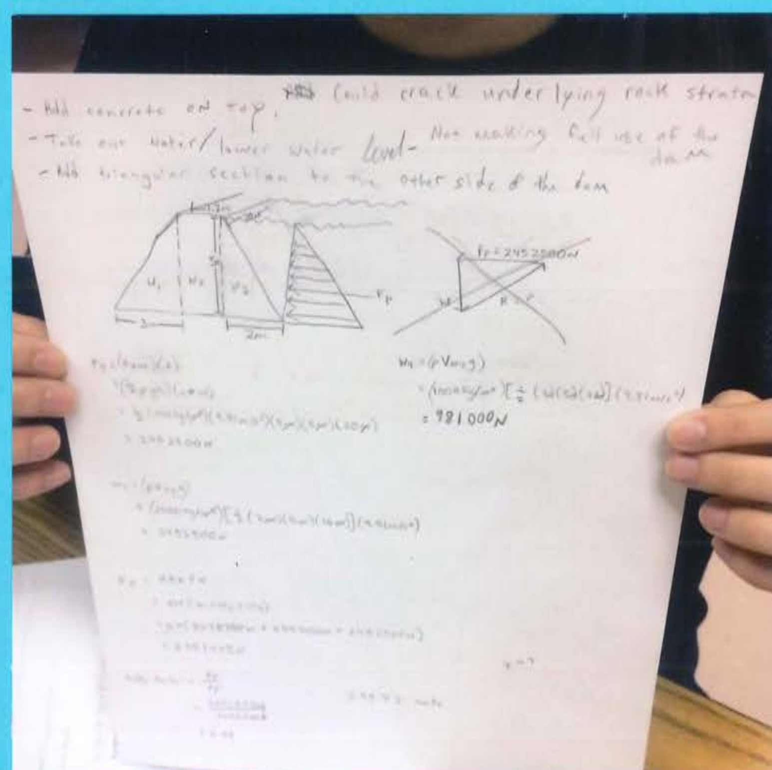


I can use exponentials to estimate the 10th and 20th year growth rate of an elk population that that was transplanted to the property after all surface mining was completed.

I can use statistical methods to estimate the number of transplanted hardwood trees that are still growing on the property at the end of a specified period of time.



I can use techniques of Vector Algebra to determine if a dam for a slurry pond can be located on the property without causing the underlying rock strata to collapse



# Music

I can compose the music lyrics of a song that has coal as a central theme.

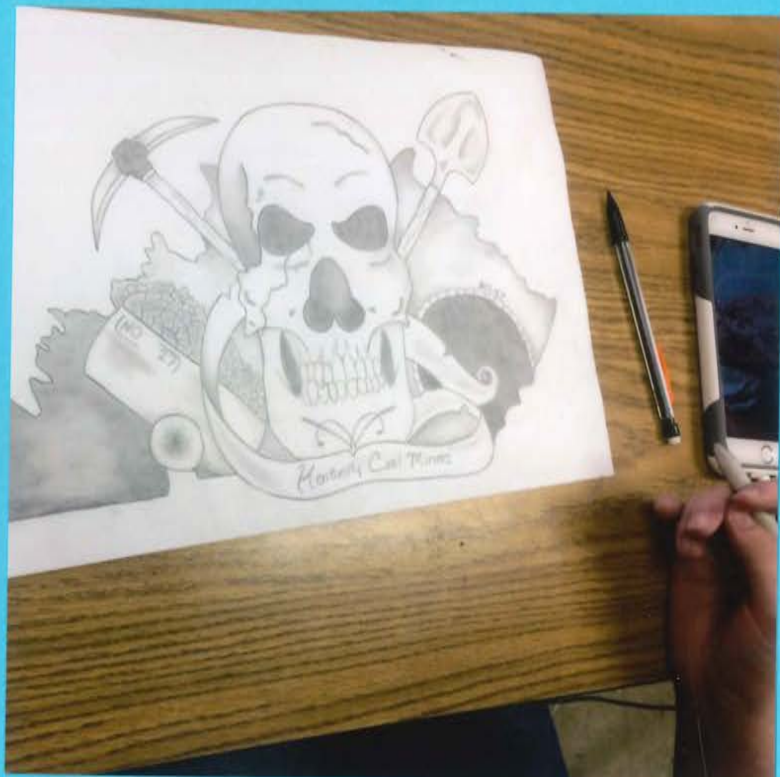
# Food Science


I can bake a cake or pastry that models the coal seam and the surrounding rock strata.

# Social Studies

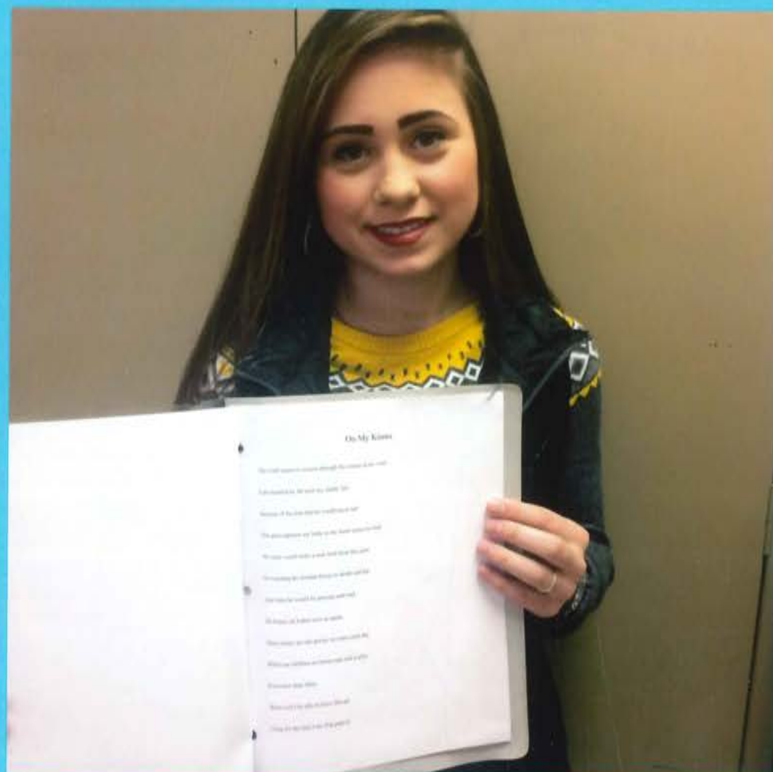
I can research the history of underground coal mining in Eastern Kentucky

# Art



I can construct a 2-dimensional or 3-dimensional work of art that is about underground coal mining.

# English



I can write a poem or short story with coal as a central theme

03-03-17

# Student Work Samples

# Future Land uses of our Abandoned Mine Property

Name_______________ Date 2-14-17 Period 5th pd

# 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?

$y = 200e^{0.22t}$

$C = 200$

$y = 600$

$t = 5$ years

$k = ?$

$\frac{600}{200} = \frac{200e^{5k}}{200}$

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

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

$0.22 = k \rightarrow 22\%$ growth

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

$t = 8$ years

$y = ?$

$y = 200e^{0.22(8)}$

$y = 1162.48$ elk

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

$t = 8.4151$ years

$C = 1162$ elk

$y = 7400$

$k = 0.22$

$t = ?$

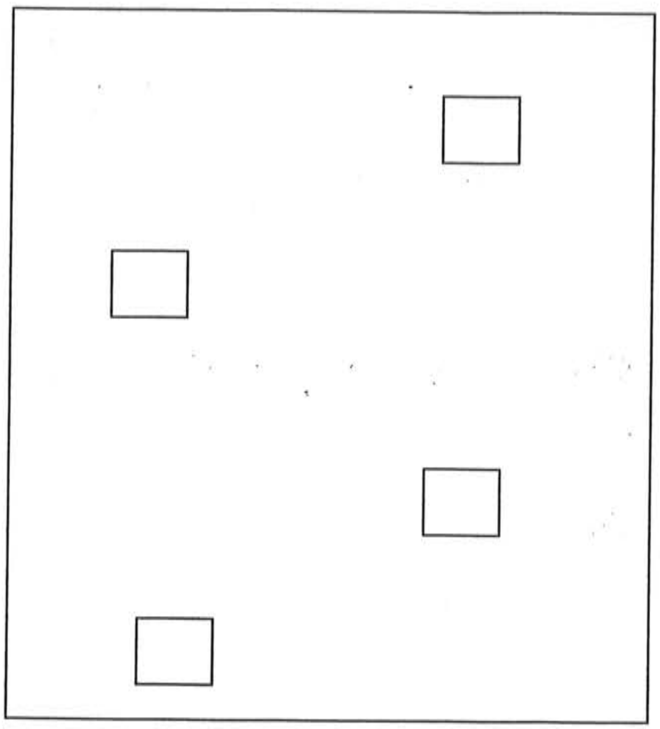
$\frac{7400}{1162} = \frac{1162e^{0.22t}}{1162}$

$\ln 6.3683 = \ln e^{0.22t}$

$\frac{\ln 6.3683}{0.22} = \frac{0.22t}{0.22}$

Example 2: The abandoned mine property in which the 1997 elk release took place was also reseeded in order to reestablish the original hardwood forest. How can we estimate the number of hardwood trees that have started growing on the property after 10 years have passed?

1. Use the graph below to determine the area of the mine property and the area of 4 small sections of the property.



Area of property = 109 hectares

Area of 4 subplots = 1.3 hectares

Number of trees on the 4 subplots =

362, 422, 486, 513 trees

$$\text{Number of trees}=(\text{Average number of trees per subplot})\ \frac{\text{Area of the property}}{\text{Area of subplot}}$$

Average

$$\frac{362+422+486+513}{4}$$

445.75

total trees

$$=(445.75)\left(\frac{109}{1.3}\right)$$

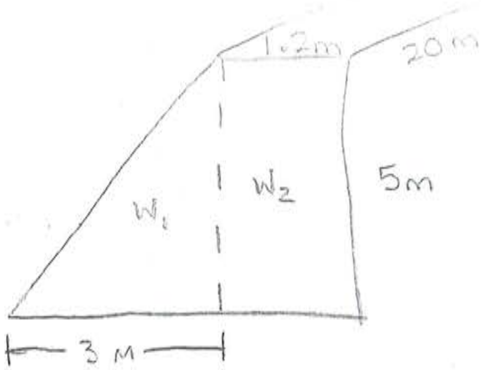
$=37374$ trees

# Determining the Safety Factor of our Coal Slurry Dam Using Vector Mechanics

$d_w = 1000\ Kg/m^3$

$\mu = 0.7$

$\rho_{con} = 2500\ Kg/m^3$




$F_P = \left(\frac{1}{2}\rho g h\right) * HW$

$= \frac{1}{2}(1000\ Kg/m^3)(9.81\ m/s^2)(5m)(5m)(20m)$

$= 2452500N$

$W_1 = (\rho V_{W_1} g) \rightarrow [\frac{1}{2}(\text{area of base})(\text{width})] = \frac{1}{2}(b \cdot h)\ w.$

$= (2500\ Kg/m^3)\left[\frac{1}{2}(3m)(5m)(20m)\right](9.81\ m/s^2)$

$= 3678750N$

$W_2 = (\rho V_{W_2} g)$

$= (2500\ Kg/m^3)[(1.2m)(5m)(20m)](9.81\ m/s^2)$

$= 2943000N$

$F_F = \mu K * F_N$

$= 0.7(W_1 + W_2)$

$= 0.7(3678750N + 2943000N)$

$= 4635225N$

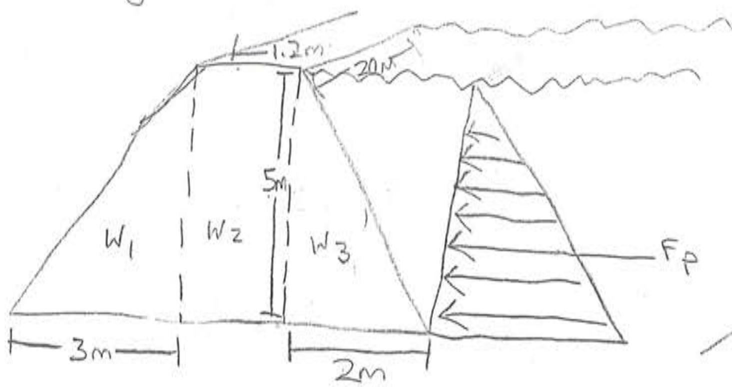
$\text{Safety Factor} = \frac{F_F}{F_P}$

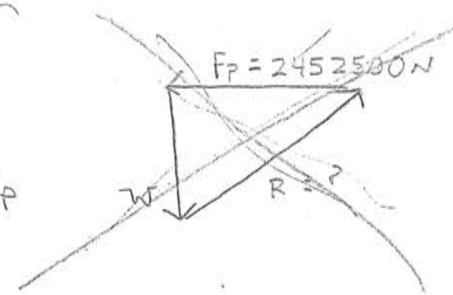
$= \frac{4635225N}{2452500N}$

$= 1.89$

1.89 < 2 therefore, Not safe

- Add concrete on top,
- Take out water / lower water level - Not making full use of the dam
- Add triangular section to the other side of the dam




$W_4 = (\rho V_{W4} g)$

$= (1000\,kg/m^3)[\frac{1}{2}(3m)(5m)(20m)](9.81\,m/s^2)$

$= 981000N$

$F_p = (P_{ave})(A)$

$= (\frac{1}{2}\rho g h)(h * w)$

$= \frac{1}{2}(1000\,kg/m^3)(9.81\,m/s^2)(5m)(5m)(20m)$

$= 2452500N$

$W_3 = (\rho V_{W3} g)$

$= (2500\,kg/m^3)[\frac{1}{2}(2m)(5m)(20m)](9.81\,m/s^2)$

$= 2452500N$

$F_F = \mu k * F_N$

$= 0.7(W_1 + W_2 + W_3)$

$= 0.7(3678750N + 2943000N + 2452500N)$

$= 6351975N$

2.47

Safety factor $= \frac{F_F}{F_P}$

$= \frac{6351975N}{2452500N}$

$= 2.59$

2.59 > 2 safe

Independent Varible

| Base of a added triangular Wedge | Safety factor | Safe or Not |
|---|---|---|
| .2 | 1.96 | NS |
| .5 | 2.065 | S |
| 1 | 2.24 | S |
| 2 | 2.59 | S |

.2

$= (\rho V_{w3} g)$

$= (2500 kg/m^3)[\frac{1}{2}(.2m)(5m)(20m)(9.81 m/s^2)$

$= 245250$

$= 0.7(3678750N + 2943000 + 245250)$

$=$ ~~6867000~~ $4806900$

$= \frac{\text{~~6867000~~ } 4806900}{2452500}$

$= 1.96$

.5 $= (2500 kg/m^3)[\frac{1}{2}(.5m)(5m)(20m)(9.81 m/s^2)$

$= 613125$

$= .7(3678750 + 2943000 + 613125)$

$= 5064412.5$

$= \frac{5064412.5}{452500}$

$= 2.065$

1 $= (2500)(\frac{1}{2}(1)(5)(20)(9.81)$

$= 1226250$

$= .7(3678750 + 2943000 + 1226250)$

$= 5493600$

$= \frac{5493600}{2452500}$

$= 2.24$

2 $(2500)(\frac{1}{2}(2)(5)(20)(9.81)$

$= 2452500$

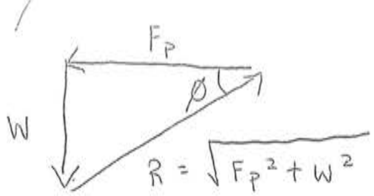
$= .7(3678750 + 2943000 + 2452500)$

$=$ ~~9074250~~ $6351975$

$= \frac{\text{~~9074250~~ } 6351975}{2452500}$

$= 2.59$

Parabolic / Curved Surface




$F_p = P_{ave} \cdot A$

$= \frac{1}{2}(\rho g h)(h \cdot w)$

$= (\frac{1}{2})(1000)(9.8)(18^2)(30)$

$= 47.6 \times 10^6 N$

---

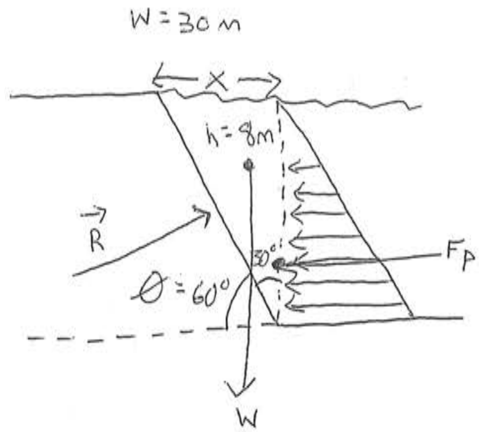
$V = \frac{1}{2} x h w$

Where $\tan 30° = \frac{x}{h}$

or $x = h \tan 30°$

$V = \frac{1}{2}(h \tan 30°)(h)(w)$

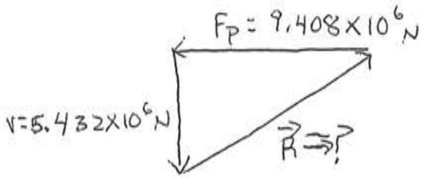
$V = \frac{1}{2} h^2 w \tan 30°$




$F_p = (P_{ave})(A) = (\frac{1}{2}\rho g h)(h \cdot w) = \frac{1}{2}(1000)(9.8)(8)^2(30) = 9.408 \times 10^6$

$W = \rho V g = \rho(\frac{1}{2} h^2 w \tan 30°) g$

$W = (1000)(0.5)(8)^2(30)(\tan 30°) = 5.432 \times 10^6 N$




$R = \sqrt{F_p^2 + w^2}$

$= \sqrt{(9.408 \times 10^6)^2 + (5.432 \times 10^6)^2}$

$= 10.86 \times 10^6 N$

$Area = 2/3 (a \cdot h)$

$W = mg = \rho V g$

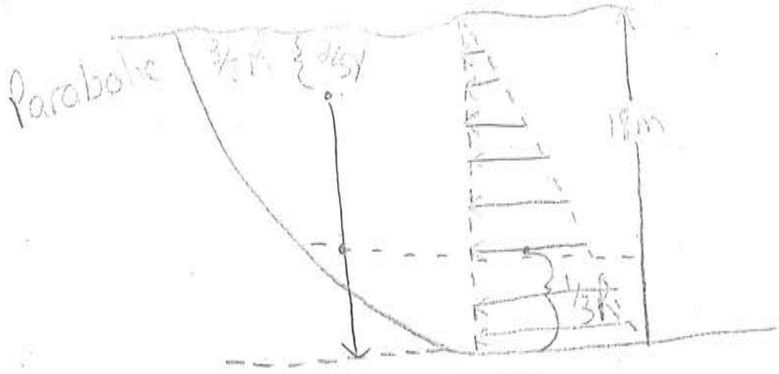
$W = \rho A W g$

$W = \rho \cdot 2/3 \, x \cdot h \cdot W \cdot g$

$= 1000 \cdot 2/3 \cdot x \cdot h \cdot W \cdot g$

$= 1000 \cdot 2/3 \cdot 10 \cdot 18 \cdot 30$

$= 35.3 \times 10^6 \, N$




$R = \sqrt{F_p^2 + W^2}$

$= \sqrt{(47.6 \times 10^6 N + (35.3 \times 10^6 N)^2}$

$R = 59.2 \times 10^6 \, N$

$y = ax^2 - 18$

$y = (\text{area of base})(\text{height})$

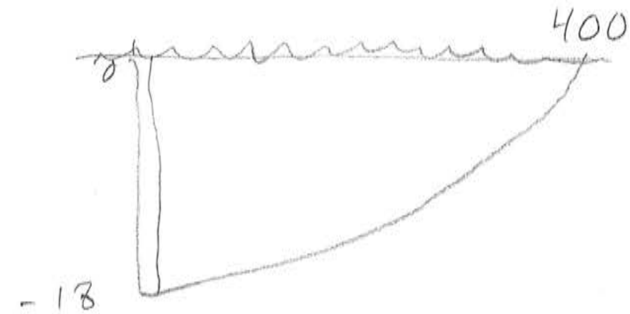
# Coal Slurry Pond

$= \text{cross sectional area}$

Dam

$y = ax^2 - 18$

$0 = a(400)^2 - 18$




$$\frac{18}{160{,}000} = \frac{a(160{,}000)}{160{,}000}$$

$a = .0001125$

$y = .0001125x^2 - 18$

$$V = \int_0^{400} (.0001125x^2 - 18)(600ft)$$

$$\int \frac{x^2}{8000} - 10800dx$$

$$1/8000 \int x^2 - 10800dx$$

$$\int x^3/3 - 10800x$$

$$\int_0^{400} .0000416x^3 - 10800x$$

$$\int_0^{400} .0000416x^3 - 10800x$$

$$[.0000416(400)^3 - 10800)] - [.0000416(0)^3 - 10800(0)]$$

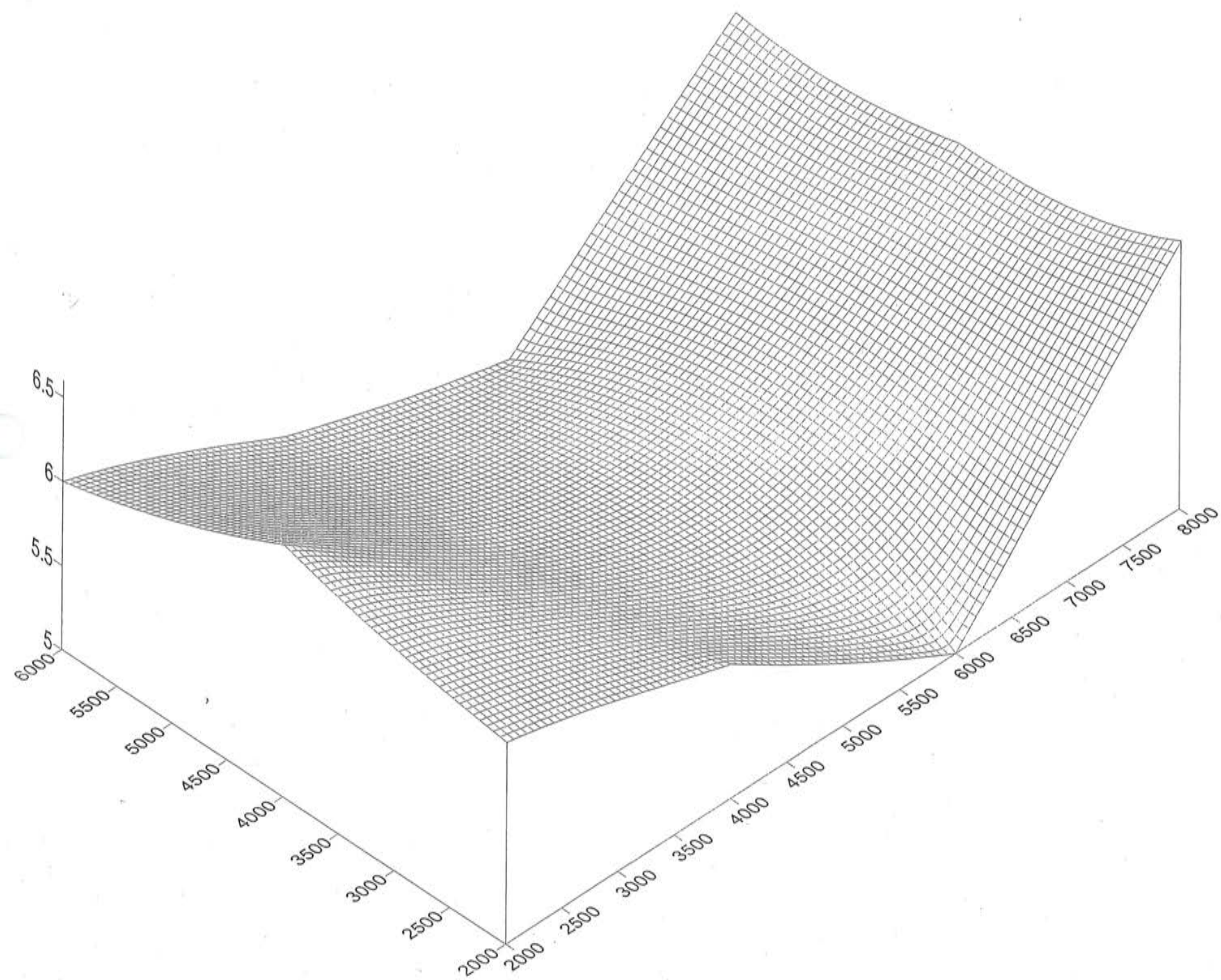
$$[(.0000416(64000000) - (4320000] - 0$$

$$2662.4 - 4320000$$

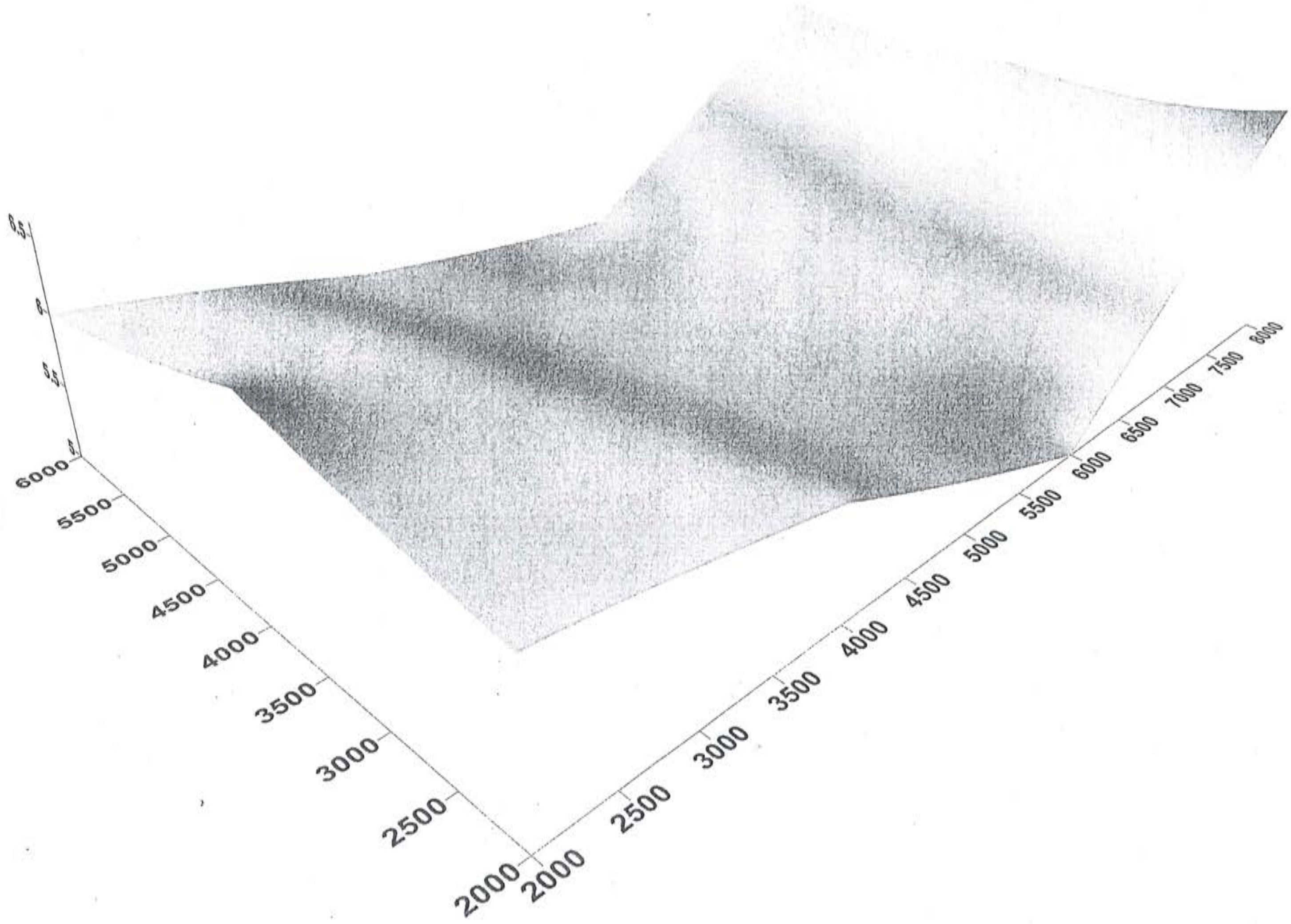
$$\boxed{-4{,}317{,}337.6 \text{ feet}}$$

03-03-17

# Modeling our Coal Seam & Volume of the Coal



6.5
6
5.5
5
6000
5500
5000
4500
4000
3500
3000
2500
2000
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000



6.5
6
5.5
5
6000
5500
5000
4500
4000
3500
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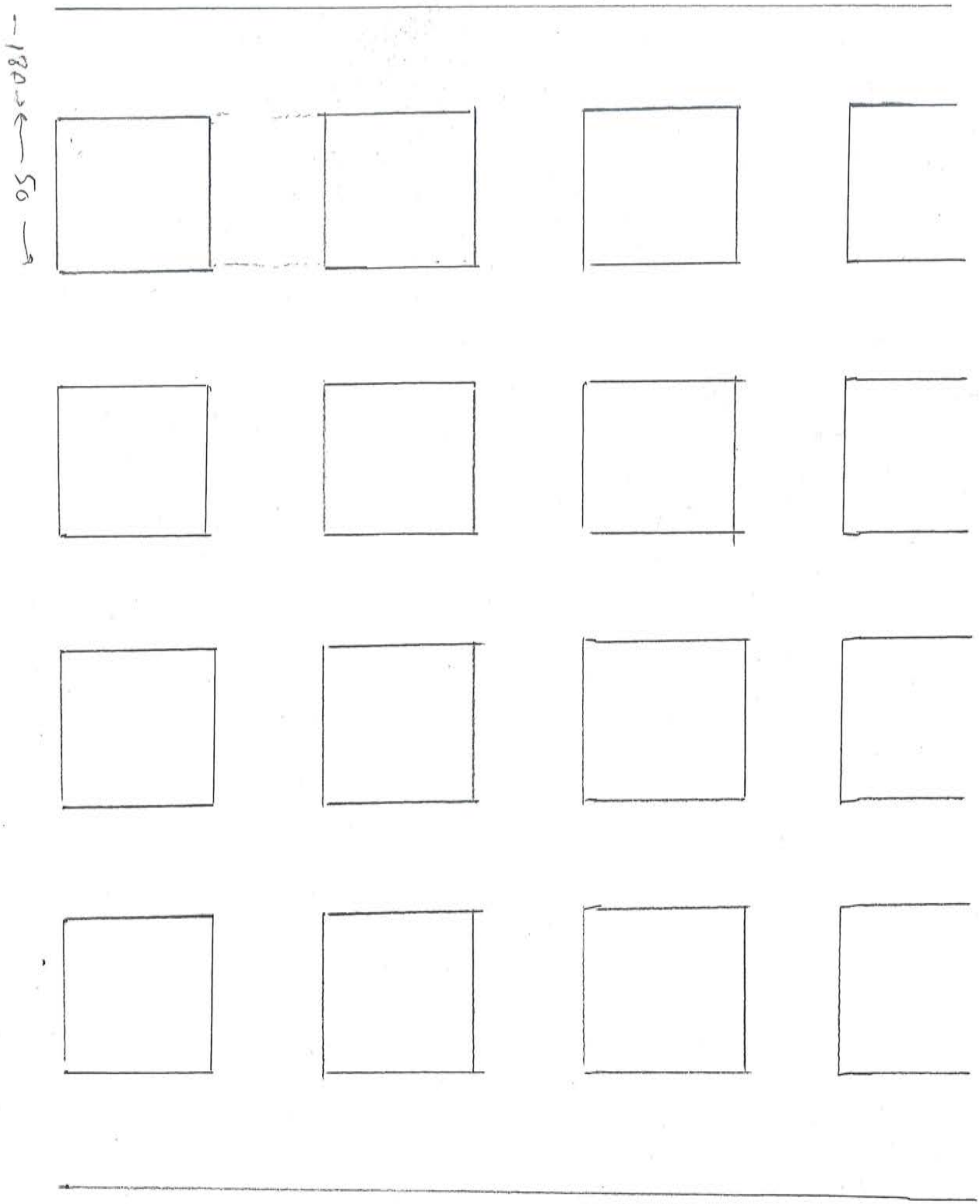
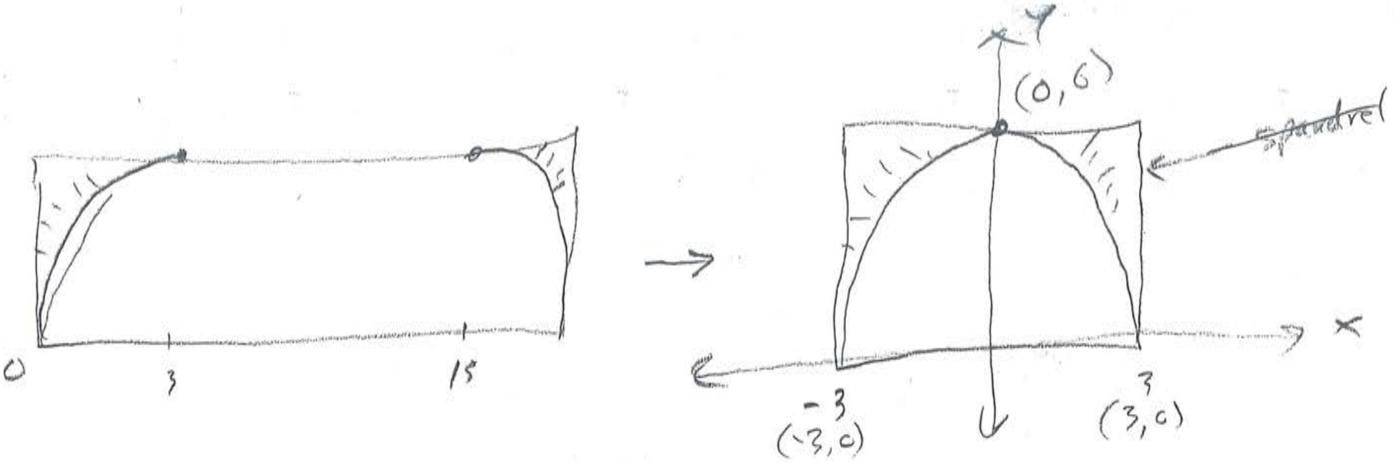
2500
2000
2000
2500
3000
3500
4000
4500
5000
5500
6000
6500
7000
7500
8000


180
50




Equation of the parabolic arch

$y = ax^2 + c$ because the graph has y-axis symmetry

$y = ax^2 + 6$ y-intercept = 6 (0,6)

Find a : use (3,0)

$0 = a(3)^2 + 6$

$0 = 9a + 6$

$-6 = 9a$

$-0.666 = a$

$-\frac{2}{3} = a$

Equation

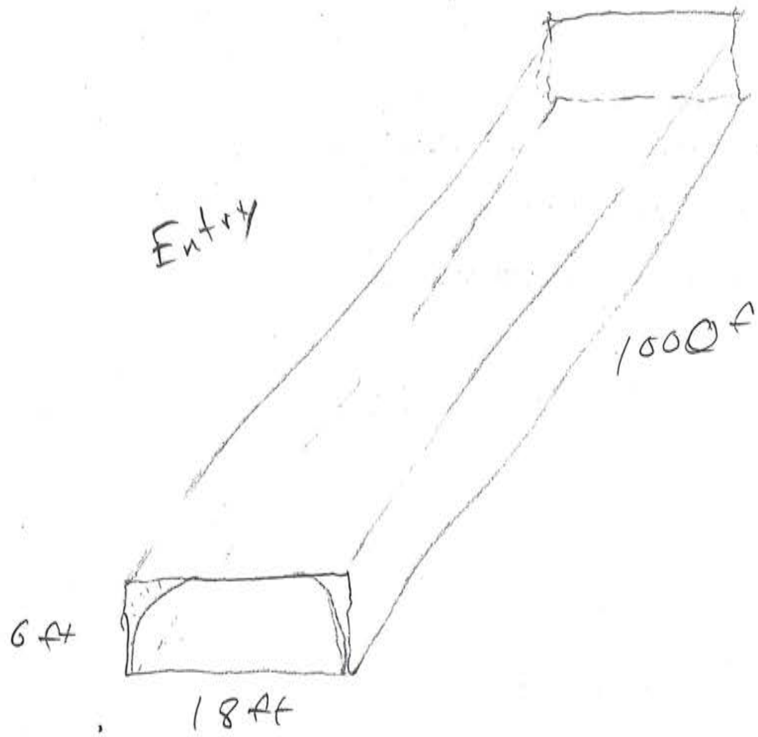
$y = -\frac{2}{3}x^2 + 6$

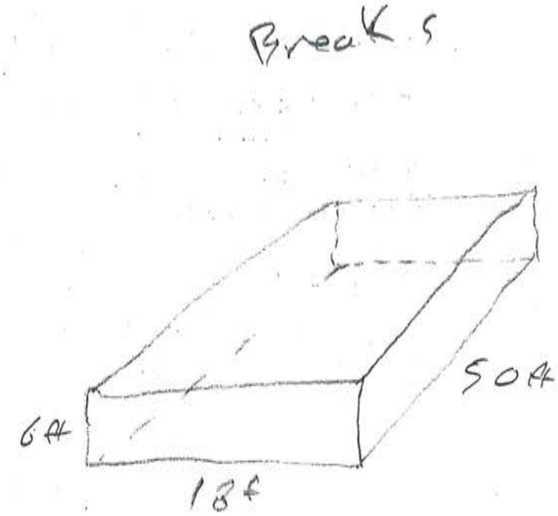
$V = lwh$

$= (18\ ft)(6\ ft)(1000\ ft)$

$= 108{,}000\ ft^3 \times 5$

$= 540{,}000\ ft$




$V = lwh$

$= 5400\ ft^3 \times 12$

$= 64800\ ft^3$

total volume

$540000 + 64800$

$604800\ ft^3$

1 Volume of ~~edu~~ coal between the mine roof and the Parabola. (coal remaining in the entry)

**Entries**

Volume = (area of Base) × (length of mine entry)

$$V = \int_{-3}^{3} (\text{Top curve} - \text{bottom curve})\, dx \cdot 1000 \text{ ft}$$

$$= \int_{-3}^{3} \left[6 - \left(-\tfrac{2}{3}x^2 + 6\right)\right] dx \cdot 1000 \text{ ft}$$

$$= \int_{-3}^{3} \left(6 + \tfrac{2}{3}x^2 - 6\right) dx \cdot 1000 \text{ ft}$$

$$= \frac{2}{3}\int_{-3}^{3} x^2\, dx \cdot 1000 \text{ ft}$$

$$\left(\tfrac{2}{3}\right)\frac{1x^3}{3}\Bigg|_{-3}^{3} \cdot 1000 \text{ ft}$$

$$\frac{2}{3} \cdot \frac{1}{3}x^3\Bigg|_{-3}^{3} \cdot 1000 \text{ ft}$$

$$\frac{2}{9}x^3\Bigg|_{-3}^{3} \cdot 1000 \text{ ft}$$

$$\left[\tfrac{2}{9}(3)^3\right] - \left[\tfrac{2}{9}(-3)^3\right]$$

$$\left[\tfrac{2}{9} \cdot 27\right] - \left[\tfrac{2}{9}(-27)\right]$$

$$6 - (-6)$$

$$12 \text{ ft}^2 \cdot 1000 \text{ ft}$$

$$1200 \text{ ft}^3$$

5 entries

$12000 \times 5$

$60000 \text{ ft}^3$

# Breaks

$$V = \int_{-3}^{3} [6 - (-\tfrac{2}{3}x^2 + 6)\, dx \quad , \quad 50 \text{ ft}$$

$$= 12 \cdot 50$$

$$= 600 \text{ ft}^3 \quad \times 12 \text{ entries}$$

$$= 7200 \text{ ft}^2$$

## Total remaining coal

$V_{Entries} + V_{Breaks}$

$60000 + 7200$

$67200 \text{ ft}^3$

volume of the coal beneath the mine roof − volume of coal below the Arch = volume of the ~~coal~~ ~~remaining~~ coal ~~below~~ missed by the miners

# Grid Volume Computations

## Upper Surface

| | |
|---|---|
| Grid File Name: | F:\CEDAR\CEDAR Grid Cordinates for 2017.grd |
| Grid Size: | 67 rows x 100 columns |
| X Minimum: | 2000 |
| X Maximum: | 8000 |
| X Spacing: | 60.606060606061 |
| Y Minimum: | 2000 |
| Y Maximum: | 6000 |
| Y Spacing: | 60.606060606061 |
| Z Minimum: | 5.0000000000339 |
| Z Maximum: | 6.5999999996014 |

## Lower Surface

Level Surface defined by Z = 0

## Volumes

Z Scale Factor: 1

### Total Volumes by:

| | |
|---|---|
| Trapezoidal Rule: | 136536415.2682 |
| Simpson's Rule: | 136535677.66279 |
| Simpson's 3/8 Rule: | 136535723.97328 |

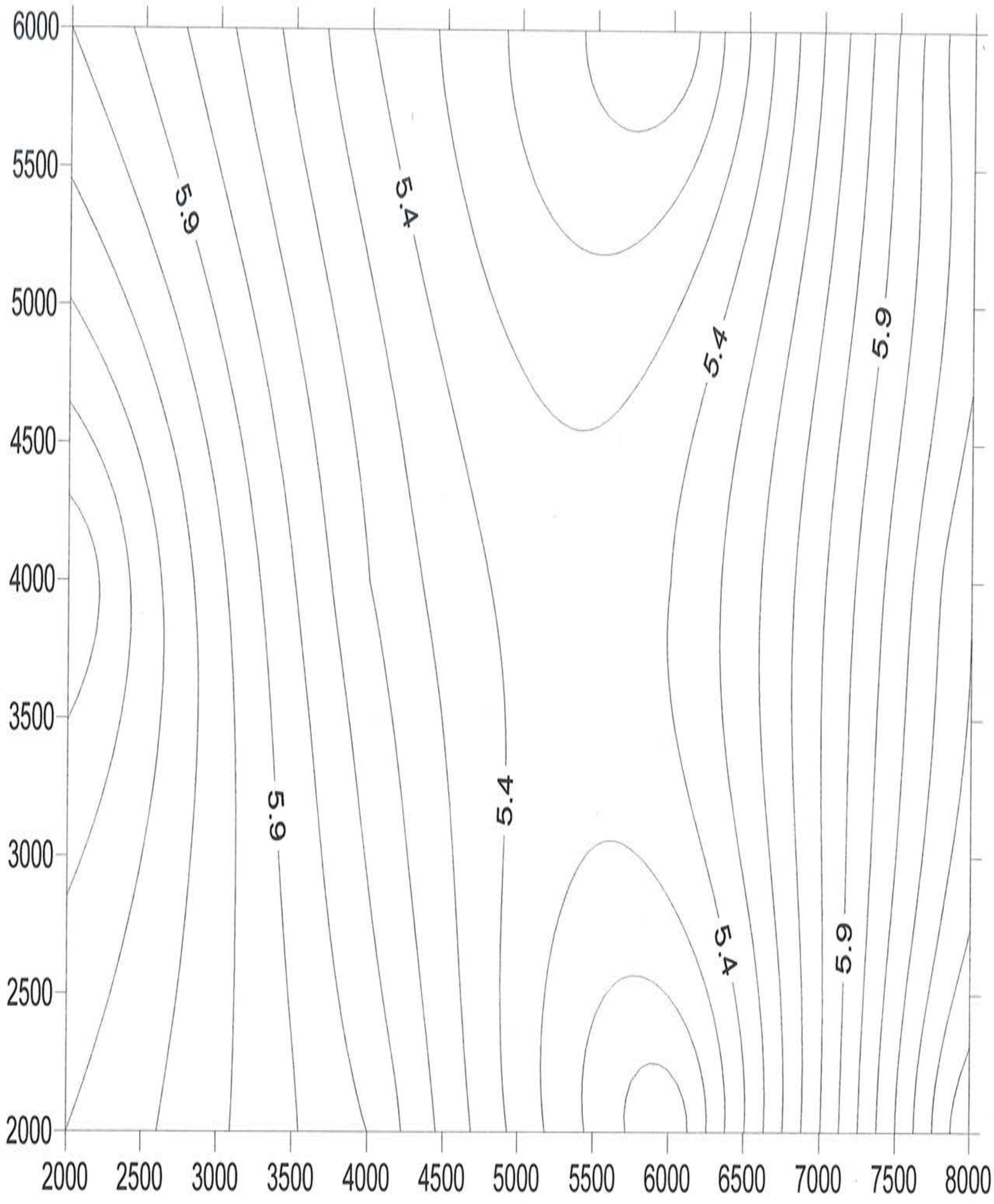
### Cut & Fill Volumes

| | |
|---|---|
| Positive Volume [Cut]: | 136536476.48645 |
| Negative Volume [Fill]: | 0 |
| Net Volume [Cut-Fill]: | 136536476.48645 |

## Areas

### Planar Areas

| | |
|---|---|
| Positive Planar Area [Cut]: | 24000000 |
| Negative Planar Area [Fill]: | 0 |
| Blanked Planar Area: | 0 |
| Total Planar Area: | 24000000 |




# Coal Seam Thickness

# Roof Bolt Size

# &

# Maximum Compressive Strength

1. Calculating the Size of My Roof Bolts

$$\text{load per bolt} = \frac{(\text{weight of roof})(\text{beam thickness})(\text{span width})(\text{length of cut})}{(\#\text{ rows} + 1)(\#\text{ bolts per row} + 1)}$$

$$\text{load per bolt} = \frac{(165)(4)(18)(20)}{(5+1)(4+1)} = \frac{237600}{30} = 7920 \text{ lb per bolt}$$

$$\frac{(\text{load per Bolt})(\text{Safety Factor})}{(45000)} = \frac{(7920)(2)}{45000}$$

$$= 0.352 \text{ in}^2$$

The area of a circle is $A = \pi r^2$. To find the radius of my roof bolts:

$0.352 = \pi r^2$
$0.112 = r^2$
$0.335 = r$
$2(0.335) = 0.67 = d$ (diameter)
Answer → 0.75 diameter roof bolts

3. The Maximum Compressive Stress (MCS) on my Coal Seam

$$MCS = \frac{(62.4)(\text{specific Gravity of shale})(\text{depth of Seam})}{144\ in/ft}$$

$$MCS = \frac{(62.4)(2.6)(380\ ft)}{144\ in/ft} = \frac{61651.2}{144} = 428\ psi$$