Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
1986 Volume VI: Fossil Fuels: Occurrence; Production; Use; Impacts on Air Quality

Mathematics:Problems on Coal and Energy

Curriculum Unit 86.06.03
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This unit is designed for seventh and eighth grade students. The purpose of this unit is a provide a historical aspect to the developments which lead to the discovery of coal and coal mining through the origins a d kinds of coal; types a d methods of coal mining, hazards of mining, measures of safety a d chemical by-products of coal.

The unit could be utilized in three separate ways. First, an instructor could use the unit as a reference and teach only one or two parts or portions of it. The information provided in the first section which is of an historical nature and where teachers are involved in team or cluster situations, could be shared with either or all the history, science, math and english teachers.

The unit is divided into three sections. The first section focuses on coal and coal mining with five different quizzes. The second section focuses on word problems and math dealing with the measurement and computation of different polygons. The final section deals with problems based upon energy and its resources.

Before the students attempt a solve the problems on energy they should solve related problems. The activities in this section are non-threatening and help a alleviate any anxieties students may have concerning the problems on coal, coal mining, energy and miscellaneous problems.

The problems are as follows :

A. Introductory

B. Problems on Coal
C. Volume and Density Calculations
D. Patio and Proportion Problems

E. Energy Problems It is not known when or by whom coal was first used. It is referred to by Greek historians as early as 300 B.C., and it was used in Great Britain as early as 852 A.D. It is supposed that the Britains were the first people a make practical use of it and coal mining was in successful operation in the island more than three hundred years before Columbus discovered America. The first discovery of coal in the United States, of which we have any record, was made by Father Hennipin near Ottawa, Illinois, in 1878. The first mine worked in the United States was Opened in Richmond, Virginia, in 1750.

Coal is a combustible rocklike substance formed from accumulations of plant matter that have undergone physical and chemical changes through geological processes. Coal varies in color from brown a black, has a dull a bright luster and may be soft or hard. Most coal occurs in large deposits called coal beds and they are made up of bands or seams separated by layers of clay, rocks and other mineral substance. The seams of the coal vary in thickness from a fraction of an inch to several hundred feet. Coal lies at various depth in the earth and some is found just below the surface of the ground. Although coal is found on every continent, it is unevenly distributed. The world's reserve supply is more than five trillion tons. Forty percent of these reserves are located in North America. (See Appendix A)

Coal is of organic origin, formed from the remains of living things such as trees, herbs, shrubs, vines and other plant materials that flourished millions of years. From this variety of vegetation and its complex carbon compounds came a great assortment of coals, from brown coal and lignite or peat to the hardest kind of anthracite.

Coal consists chiefly of carbon, derived directly from organic carbon compounds. It is fossilized plant material, preserved by burial and altered by earth forces. The character of a coal depends Upon the nature of the original plant debris. The different types of coal are lignite, subituminous, bituminous and anthracite.

Some coal was formed millions of years ago. The most high ranked coal was formed more than two hundred fifty million years ago, during the carboniferous period. At that time a warm moist climate prevailed and swamps covered a large part of the world. The air was damp and steamy. Most of the plants were huge strange-looking ferns, reeds, mosses and trees that had no flowers. As these plants died, others grew on top of them. The accumulation of this partly decayed plant matter formed a brown fibrous material called peat, the first stage in the formation of coal.

Variations in the conditions under which coal is formed result in different varieties of coal. Coal has no fixed chemical composition but varies according to the composition of the original materials and the state of development reached in the coal-forming process.

The plant materials from which coal is formed consist primarily of carbon, hydrogen, and oxygen. Under heat and pressure, the hydrogen and oxygen are driven off in the form of water and gases, such as carbon dioxide and methane. The material that remains is composed mostly of carbon. The more heat and pressure applied, the greater the percentage of carbon that remains and the harder the coal.

Coal also contains varying amounts of water, combustible gases and other volatile materials, and mineral impurities. Common mineral impurities include sulfur, silica, iron sulfide, calcium and magnesium carbonates, phosphates and clay. These remain in the ash when coal is burned.

The amount of heat produced when coal is burned depends on the composition of the coal. The heating value of coal is measured in British thermal units (B.t.u.). One British thermal unit is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit, usually from 38° F. a 40°. (See Appendix B&C)

Coal is graded in “ranks” according to the percentage of carbon it contains. Generally, the higher the rank, the higher the percentage of carbon and the lower the percentage of volatile materials and moisture in the coal. The principal ranks of coal are anthracite, bituminous lignite.

Anthracite. Anthracite, the highest rank of coal, contains the highest percentage of carbon and the lowest percentage of mineral impurities and volatile materials. Anthracite is a hard, shiny, black coal that burns with a short, blue, smokeless flame. It is valuable as a home fuel because it leaves very little ash and has a high heating value, from 12,700 to 13,700 B.t.u. per pound.

Bituminous Coal . Bituminous coal, the next rank, is subdivided into semibituminous, bituminous, and subbituminous coal. Semibituminous coal is a hard, black, lustrous coal with a high carbon content. Because it has a high heating value and burns with very little smoke, it is widely used for heating homes and other buildings.

Bituminous coal has a lower percentage of carbon and contains more moisture than semibituminous coal. It is soft to hard, is dull to shiny black, and burns with a long, smoky flame. Some bituminous coal, called coking coal, is used to make coke. An other kind, called gas coal, is used to produce combustible gases.

Subbituminous coal is usually dull brown or black in color, is soft, and flakes into thin pieces. It burns with a long, smoky flame and is used to produce steam.

The heating values of the three bituminous types range from 9,500 to 14,000 B.t.u. per pound. Bituminous coals are the most plentiful and widely used of all coals. There are bituminous coal deposits on every continent. (See Appendix D)

Lignite . The lowest rank of coal is lignite, also called brown coal, because of its color. Lignite has the lowest percentage of carbon and the highest percentage of moisture, volatile materials, and mineral impurities. It has a soft, woody texture and crumbles easily when dry. Lignite burns with a long, smoky flame and has a relatively low heating value, ranging from 6,700 to 8,300 British thermal units per pound. Lignite is sometimes dried and pressed ink briquets for use in fireplaces. Nearly all the lignite mined is used to produce steam and electrical power.

Coal is also classified by the material from which it is formed. Different types of coal are produced from different plant materials. Three common types of coal are banded coal, cannel coal, and splint coal. Each rank may theoretically include coal of each type but seldom does.

Banded coal has visible layers of various materials and often contains a highly lustrous substance called vitrain. The bands are formed by the different layers of plant material from which the coal was formed. Most bituminous coal is banded.

Cannel coal is unbanded and uniform in texture. It has a silky or greasy luster and usually is formed from spores and pollen grains. Cannel coal ignites easily and burns with a bright flame.

Splint coal is dull, with fine ridges. It is hard and has a metallic ring when struck. Splint coal is used as fuel for steam power plants.

Deposits of coal vary in thickness from less than 1 inch to more than 100 feet. Most coal is mined from beds which are from 2 1/2 to 8 feet thick. These deposits are sometimes called seams (veins), but geologists prefer to use the word bed, because coal was formed in wide bedding areas. Coal deposits are sandwiched between layers of rock and dirt. The deposits may be level, sloping, or tipped on end, depending on whether they have been affected by the cracking and folding of the earth's crust. Coal beds may lie deep in the ground or near the surface. In hilly or mountainous country, the coal often is exposed on the hillside. But it is likely to be covered with dirt or weathered from exposure and hard to recognize. Excavations for buildings or highways frequently uncover coal beds. Sometimes coal is found in drilling for water, oil, or gas. But the principal method of locating coal is to use core drillings. This is done by drilling out a core (column) from the earth's crust to indicate, layer by layer, what is under ground.

Coal beds are made up of bands, or seams, of coal separated by layers of clay, rock, shale, or other mineral substances. The seams vary in thickness from a fraction of an inch to several hundred feet. Most of the coal beds mined in the United States have seams 3 to 7 feet thick, but the great anthracite bed is 50 to 60 feet thick, and some beds of brown coal are over 300 feet thick.

Coal lies at various depths in the earth. Some coal is found just below the surface of the ground. Geologists estimate that some coal reserves lie as deep as 6,000 feet beneath the earth's surface. In the United States many large coal beds are close to the surface, but in Great Britain most of the coal lies at great depths. Coal seams may be flat or sharply folded because of the buckling and shifting of the earth.

Coal, although found on every continent, is unevenly distributed. According to an estimate of the U.S. Bureau of Mines, the world's reserve supply of coal is more than 5 trillion tons.

There are two general methods of mining coal: underground or deep mining, and surface or strip mining. Underground mining is of three types, depending on the nature of the terrain, the thickness of the coal seam or vein and on whether the coal is embedded in a hilly or a mountainous country or in flat areas. These are shaft mining, drift mining, and slope mining. The methods of mining are, room-and-pillar-and-breast techniques and hard-and-pillar system.

There are two general methods used to mine coal. These are (1) strip (surface) mining, and (2) underground (deep) mining. Miners usually use strip mining when the coal beds lie close to the surface of the earth. Otherwise, they use underground mining methods.

Strip Mining

In this method, giant power shovels or other earth-moving equipment remove the overburden, the layer of earth and rock that covers the coal seam. When the coal is exposed, it is broken up usually by explosives, and loaded by smaller power shovels into huge trucks. The trucks carry the coal to preparation plants. Strip mining is fast and efficient. However, it can ruin the appearance or an area and leave banks of land exposed to erosion. For these reasons, many states have restricted strip mining or required that the land be made productive again after it has been mined. The coal industry has developed many ways of reclaiming strip-mined areas, including planting crops on the land or turning it into a recreation area.

Underground Mining

Includes several types of mines. The most important of these are (1) shaft mines, (2) drift mines, and (3) slope mines. Each type of mine is best suited to removing the coal from a particular type of coal bed. (See Appendix E & G)

Shaft Mines

Reach coal beds that lie far below the earth's surface. A hole is dug straight down to the coal. The miners then dig horizontal entries through the seams of coal. Elevators carry the miners, equipment and coal between the coal seam and the surface. Separate shafts are dug to provide ventilation for the working rooms far underground. The average depth of shaft mines in the United States is 260 feet.

Drift Mines

They are also used to reach coal beds in hillsides. The entrance is located where the coal is exposed on the hillside, and the tunnel is dug through the coal bed.

Slope Mines

They are also used to reach coal beds in hilly areas. Miners open a sloping tunnel through the ground to the coal bed level. The miners and their machines are moved in and out of the mine on cars that are pulled by electric locomotives along steel tracks. Coal is taken out in similar cars, or by conveyor belts.

Coal is mined according to a definite plan. The plan must allow as much coal to be removed as possible, in the safest and most efficient way possible.

The wall of the bed from which the coal is taken is called the mine face. In cutting into this mine face, there are two general mining systems: (1) the room-and-pillar system, and (2) the longwall system.

Room-and-Pillar Mines are composed of a series of rooms cut into the coal bed from numerous entries. The miners leave pillars (columns) of coal standing to help support the roof until they mine cut a particular area. Then, as the miners move back to the main entry they systematically remove the pillars and permit the roof to fall. This system is used in most of the underground coal mines of the United States.

Longwall Mines are common in Europe and are now found in the United States. In this system, coal is mined by a machine which is pulled back and forth across a face 240 feet or more in length. The loosened coal falls onto a conveyor belt which carries it away. Moveable steel props support are advanced. The roof behind is allowed to fall. Miners equipment, and coal move to and from the face through haulageways that open along each side of the face. One advantage of the longwall system is that almost all of the coal can be removed because no pillars are left standing.

After the coal has been mined it is hauled to the surface. Two or three types of haulage equipment are used to deliver the coal to the surface or to the hoisting facilities. Shuttle cars, which are electrically powered rubber-tired trucks, receive the coal from the loading machine and relay it to the next haulage unit. This unit is commonly a belt conveyor, called a panel conveyor, that feeds the coal to a mainline conveyor or to the mine railway. In many mines, however, the shuttle cars deliver to cars on the mine railway. These cars are then pulled by electric locomotives 7 to 10 miles to the surface or to the hoisting facilities.

Coal is transported by rail in large open cars called gondolas or hoppers. Mines rear waterways is often shipped by barge, a less expensive method than railway transportation. Coal may be moved to ports by rail and then shipped to its final destination. Trucking coal is less expensive and convenient for short distances. It is also moved by pipeline.

Coal is the source for many chemical products, most of them by-products of the carbonization or coking process. There are believed to be more than 200,000 chemical by-products. Aside from physical warmth and comfort coals principal by-product is coke, which makes possible the manufacture of steel and thousands of other products. The refrigerants, carbon dioxide for dry ice and ammonia, the synthetic in electric refrigerators are coal derivatives. All edible dyes and hundreds of medicine and antiseptics are produced from coal.

OBJECTIVE

To develop the concepts of area and formulas for finding the area of squares, triangles, parallelograms, circles, cubes and other polygons.

To develop concepts of volume and surface area. Example: cylinder, rectangular prism.

Identify quadrilaterals and polygons and compute the answers. Make use of a protractor to draw parallel lines, perpendicular lines, squares and triangles.

TEACHING SUGGESTIONS

Draw a grid on the board and indicated a rectangle. Find the area of the rectangle by counting the squares and demonstrate that multiplying the base times the height gives the same result.

Distinguish between appropriate units for expressing length and area. Caution students that problem solving may require more than one step.

Demonstrate with a,b,c, blocks that the volume of a box in cubic units is the number of cubes that the box holds. Use the blocks to build rectangular prisms of varied dimensions. Have the students count the number of blocks in each layer and then compute the volume of each prism.

Draw several polygons including a triangle. Have students measure them and compute the answers. Define a parallelogram as a quadrilateral with opposite sides parallel, a rhombus as a parallelogram with all four sides equal, a rectangle as a parallelogram with right angles and a square as a rectangle with four equal sides. Have students draw an example of each labeling the sides and angles to justify their choices.

INTRODUCTORY PROBLEMS

SQUARE

The area of a square is equal to the length of its side times itself or the side squared. Formula: $A=s^2$

(figure available in print form)

1. What is the area of a square whose sides is 23 feet?

2. Find the area of squares whose sides measure: (a) 15 yd, (b) 42 in. (c) 320 rd., (d) 7,090 ft., (e) 1,760, (f) 0.64 mi., (g) 39.37, (h) 20 1/2 ft, (i) 6 3/8 in., (j) 5 ft. 8 in.

RECTANGLE

To find the area of any rectangle, multiply the measure of the length times the width. Formula: Area= length x width.

(figure available in print form)

1. What is the area of the following rectangle whose measurements are:

(a) length=20 cm	width=10 cm
(b) length=15 m	width=35 m
(c) length=5 mm	width=9 mm

PARALLELOGRAM

To find the area of a parallelogram, multiply the base times the heights. Formula: A = b x h

1. What is the area of the following parallelogram?

(a) base = 400 cm	height = 24 cm	A= bxh	400	
(b) base = 12.5 m	height = 1.42 m	A=24x400	x 24	
(c) base = 14 mm	height = 7 mm	A=9600cm	1600	
				800
		Answer:9600cm	9600cm	

TRIANGLE

The area of a triangle is equal to one half the altitude times the base. Formula: A = 1/2 ab or A = a x b

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1. Find the Area of a triangle with an altitude of 26ft. and a base of

17ft.	A=1/2 ab
a=26’	A=1/2x(26x17)
b=17’	A=221 sq. ft.
	Answer: 221 sq.ft.

(figure available in print form)

Find the areas of triangles having the following dimensions.

altitude	20 in.	26 1/2 ft.	4.8yd.
base	15 in.	2 1/2 ft.	3.4yd.

(figure available in print form)

TRAPEZOID

The area of a trapezoid is equal to the height times the average of the two parallel sides. Formula: A = h x(b + b2)

2

(figure available in print form)

1. Find the area of a trapezoid with bases of 44 inches and 36 inches and a height of 30 inches.

(figure available in print form)

A= 30x(44+36)	44	
2	+36	Answer:1,200 sq.in.
A= 30x40	80	
A=1,200 sq.in.	80-2=40	

Find the areas of trapezoids having the following dimensions.

heights	8in	5ft	18ft.	6ft.	10in.
upper base	4in.	9ft.	29rd.	11 3/4 ft.	1ft.
lower base	10in.	13ft.	36rd.	14 1/2 ft.	1ft. 4in.

DISCOVERING ¹

1. Using a set of circles cut out of wood (circles approximately 8cm., 14cm., and 20cm. in diameter, for example) and a tape measure graduated in millimeters, measure the diameter and circumference of each. For each circle divide the circumference by the diameter.
2. Draw circles 8cm., 14 cm., and 20cm., in diameter on a piece of graph paper ruled in millimeters. Determine the area of each circle by counting the number of square millimeters in each. For each circle divide the area (in square millimeters) by the square of the radius (in millimeters).
3. Measure the diameter and volume of wooden spheres of three different diameters. This measurement can be made by immersing the spheres in water contained in graduated cylinders; the volume of water displaced is the volume of the spheres. For each sphere divide the volume by 4/3 times the radius cubed.
4. The answer Obtained in each of these calculating should all be slightly greater than 3. If all of the measurements are made with a high degree of accuracy the answers would be very close to 22/7. This number appears frequently in studies of sciences and it is designated by the Greek symbol ¹. This number has been determined with great accuracy; to nine decimal places, for example, it is equal to 3.141592654. You have now learned the following:

(figure available in print form)

For a circle;

circumference = ^{1} x (diameter) $C = {}^{1} D$

area = ^{1} x (radius squared) $A = {}^{1} R^{2}$

For a sphere

volume = 4/3 ^{1} x (radius cubed) $V = 4/3\ {}^{1} R^{3}$

For each of the following diameters calculated the circumference and area of a circle and the volume of a sphere: 25cm. (the diameter of a dinner plate); 66cm. (the diameter of a bicycle wheel); 8,000 feet (the diameter of the earth).

Sphere

The volume of a sphere is equal to 4/3 times pi (^{1}) times the cube of the radius. Formula $V = 4/3\ {}^{1} r^{3}$.

Sometimes the formula $V = {}^{1}d^{3}$ is used.

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1. Find the volumes of spheres having the following radii:
   a) 40 in b) 66ft c) 12.4 yd. d) 2 1/2 in.
2. Find the volume of spheres having the following diameters:
   a) 25 ft. b) 74 in. c)10.2 ft. d) 8 1/2 in.

VOLUME

The volume of a cube is equal to the length of the edge times itself times itself or the edge or side cubed. Formula: $V = e^{3}$ or $V = s^{3}$.

1. Find the volume of a cube whose edge measures 17 inches.

(figure available in print form)

V=e3	17	289
$V=(17)^{3}$	x17	x17
V=17x17x17	119	2023
V=4,913 cu.in. 17	289	
	289	4913

Answer:4,913 cu.in.

2. Find the volumes of cubes whose edges measure:
   a) 10ft. b) 15in. c) 11 1/2ft. d) 28ft. e) 1.08yd.
   f) 0.38 in. g)4 1/2ft. h) 5 3/4yd. i) 6yd. j) 7 1/2in.

CONSUMER PROBLEMS

1. A microwave oven uses 1.5 kilowatt hours of electricity in 30 minutes. How much electricity does it use in 3 hours?
2. The January electric bill was $142.60, which was twice as much as the December bill. The February electric bill was $20.00 higher than the December bill. What was the total cost of electricity for the three months?
3. Allen Williams is paid overtime for his work as an electrician. His basic pay is $12.00 an hour. Any time over 40 hours is one and a half times his basic pay. What will Allen earn if he works 48 hours this week?
4. Christopher bought 300 shares of coal mine stock for $20,550.00 when the price of the stock went up, he sold it for $216.00 a share. What was his total profit on the stock?
5. Gregs family spends $200.00 a month on heating. They use 25 50-lb bags of coal and $90.00 worth of oil. How much does a 50-lb bag of coal cost?
6. a. A coal miner is expected to work 48 hours each week. The miner would earn $12.00 an hour for the first 40 hours. The miner would be paid one and a half times his hourly wage for the 8 hours overtime. How much would he earn in overtime? What would his total salary for the week, for the month, for the year?

    b. What is his gross income?

7. Coal produces ash, Each grade of coal contains its own amount of ash. If 400 pounds of ash are left after burning two tons of coal, how many pounds, of ash would be left after burning 8 1/2 tons of coal?
8. It cost the Brown Family 16 cents a day for lighting the entire household, five cents each for cooking three meals on an electric range, and 70 cents a day for running an electric hot water heater. What is the Brown’s family electric bill for one day, for a month and a year?
9. In 1980 the average revenue per kilowatt-hour sold to residential customers was 5.36 cents. Today it cost 2 1/2 times as much. What is the cost today?
10. It cost a half penny to run a combination radio/phonograph for an hour. How much does it cost to run a radio/phonograph for 5 3/4 hours?

TOPICS FOR PROBLEMS IN SCIENCE AND MATHEMATICS

LENGTH AND VELOCITY

1. You can measure length with a ruler or measuring tape. A simple and convenient way of measuring lengths is by determining the length of your stride. Using a yardstick or measuring tape mark two points on the ground or sidewalk or street a distance of 100 feet apart. Then walk at your natural pace between the two points, counting your steps. Calculate the length of your stride.
2. Walk around a square or rectangular block near your home or school, counting the number of steps you take in walking along each side. Calculate the length of each side.
3. Another convenient way of measuring length is by using your bicycle. Mark a spot on the rear tire with chalk or a bandaid. Then push your bicycle over a marked distance of 100 feet and count the number of revolutions made by the rear wheel. How far does your bicycle move during one revolution of the rear wheel?
4. Measure the length of each side of the block that you used in problem 2 by using your bicycle and compare with the answers you obtained in problem 2.
5. Take a walk on a long straight street where you can turn around and look back to your starting point. Stop and look back when you have walked a fourth of a mile (1,320 feet), half a mile (2,640 feet), and a mile (5,280 feet). Take a watch along and determine how long it takes you to walk a mile. How many miles could you walk in one hour at the same pace?
6. What is the distance around the athletic field at your school? What are the length and width of a football field? A tennis court?
7. Let's find out how tall a tree is without climbing it. First get a piece of plywood and cut it into this shape:

(figure available in print form)

so that the sides a and b are each 12 inches. Now pick out a tall tree on flat ground. Starting from the trunk of the tree, walk away from it in a straight line, counting your steps. After you have walked a short way turn around and face the tree. Hold the wooden shape so that your eye is at corner d and side b is horizontal. Sight along side c pointed toward the top of the tree. Continue until side c points to the top of the tree. Then the distance you have walked is the height of the tree.

8. A tree casts a shadow (AB) of 26ft. while a 3-foot post (EF) nearby casts a shadow (DE) of 2ft. What is the height (BC) of the tree?

(figure available in print form)

9. How fast is the rear wheel of your bicycle turning when you are riding at a speed of 20 miles per hour?

10. Using a tape measure determine the diameter and circumference of each of several circles. For each one calculate the ratio of the circumference to the diameter. Does it depend on the size of the circle?

11. Determine how fast you can ride on your bicycle by measuring a one-mile distance and then riding along it as fast as you can, using a stop watch to determine how long it takes. How many miles could your travel in an hour?

ENERGY PROBLEMS

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1. What is the highest rate at which you can do mechanical work? One way to measure this is to use a stopwatch to determine how much time is required for you to climb one or more flights of stairs. First, measure the height (in feet) of the stairs that you are going to climb. Then climb them as fast as you can and measure the time with a stopwatch.

a. the amount of energy that you have expanded, expressed in foot-pounds, is numerically equal to the product of your weight (in pounds) and the height (in feet) of the stairs. Calculate this quantity.

b. the rate at which you have expended energy is the number of foot-pounds calculated in part (a) divided by the time (in seconds). Calculate this quantity in foot-pounds per second.

c. one horsepower is defined as 550 foot-pounds per second. Calculate by number of horsepower you were exerting dividing your answer in (b) by 550.

NOTES TO REMEMBER

energy = (weight in pounds) x (vertical distances in feet)
power = (energy)—(time)
horsepower = (power)—(550)

2. How much energy (in foot-pounds) would be required to lift 1800 cubic feet of water through a vertical distance of 9Oft? If you want to left this water in 18 seconds at what rate (in foot-pounds

per second) will energy be expanded? How many horsepower is this? (1 cubic foot of water weights about 62 pounds).

3. Now think about the reverse process, i.e., about water falling. The falling water can be made to do work by having it flow through a device called a turbine and turn a shaft that operates some kind of machinery. The rate at which energy is recovered is given by the following formula:

Power=(rate of flow, pounds per second)x(vertical distance, feet).

Consider a river flowing at a rate of 150,000 cubic feet per hour. By building a dam at the right place we can create a drop in elevation of 80 feet. How much power (in foot-pounds per second) can the falling water generate? How many horsepower is this?

4. One horsepower is equal to about three—fourths of a kilowatt. If the energy of the falling water in problem (3) is converted to electricity, how many kilowatts could be generated?

RATIO AND PROPORTION PROBLEMS

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1. When carbon is burned in air 12 parts by weight, carbon reacts with 32 parts by weight, oxygen to yield 44 parts by weight, carbon dioxide, i.e.

12 grams carbon reacts with 32 grams oxygen to yield 44 grams carbon dioxide.

12 kilograms carbon reacts with 32 kilograms oxygen to yield 44 kilograms carbon dioxide.

12 pounds carbon reacts with 32 pounds of oxygen to yield 44 pounds carbon dioxide. How much oxygen reacts and how much carbon dioxide is formed when 660 kilograms of carbon is burned?

2. When hydrogen is burned in air, 2 parts by weight, hydrogen reacts with 8 parts by weight oxygen to yield 18 parts by weight water. How much oxygen reacts and how much water is formed when 30 kilograms, hydrogen is burned?

3. When sulfur is burned in air, 32 parts by weight, sulfur reacts with 32 parts by weight, oxygen to yield 64 parts by weight sulfur dioxide. How much oxygen reacts and how much sulfur dioxide is formed when 30 kilograms sulfur is burned?

4. The coal burned in a power plant has the following analysis:

	% by weight
Carbon	66
Hydrogen	3
Nitrogen	1
Sulfur	3
Moisture	11
Ash	16

Calculate the quantities of carbon dioxide, water, and sulfur dioxide formed when one metric ton (1000 kilograms) of this coal is burned.

5. The power plant burns the coal described in the proceeding problem of a rate of 35 metric tons per hour, and it is operated 7800 hours per year. Calculate the weight of ash produced in one year in metric tons. One metric ton is equivalent to 2200 pounds. Calculate the weight of ash produced in one year in pounds.

6. The density of ash is 110 pounds per cubic foot. Calculate the volume of ash produced in one year.

7. If the ash produced in one year were spread out on flat land in a layer 1ft. thick calculate the land area that would be required. Express your answer in square feet and also in acres.

8. A farmer in a Western State owns a track of land of 640 acres, or one square mile. He now uses the land for farming and grows crops that sell for $9,000 each year. A few feet below the surface is the top of a layer of coal 17 feet thick that can be recovered by strip mining. The coal has a density of 75 pounds per cubic foot.

a. calculate the weight in tons of coal in this deposit.

b. calculate the total value of the coal deposit if it is worth ten dollars per ton.

c. how does the value of the coal compare with the value of crops that could be produced in 100 grams?

9. A power plant can be provided with either of two coal supplies:

	Heating Value B.t.u. per lb.
Bituminous	11,000
Lignite	8,000

a. The bituminous coal is available at $50 per ton (delivered). How much could the company afford to pay for lignite (delivered)?

b. For each of these coals how many pounds of SO2 would be formed by the amount of coal required to yield 10^6 B.t.u. in a furnace?

10. Consider that the average productivity of a miner in a strip mine is 36 tons of coal per day and that of a miner in a deep mine is 12 tons of coal per day. Assume that each works an average of 200 days per year. Calculate the number of strip miners that would have to be added to the work force to produce an additional 5 quads of energy per year, assuming an average heating value for the strip-mined coal of 8,000 B.t.u. per lb. Repeat for deep miners, assuming an average heating value of 11,000 B.t.u. per lb. for deep-mined coal.

MISCELLANEOUS PROBLEMS

1. A mile is 5,280 feet. A square mile is equivalent to 640 acres. Calculate the number of square feet in one acre.
2. A coal-fired power plant uses 2,500,000 tons of coal per year. The coal contains 16.71% ash by weight. How many tons of ash are produced in one year? How many pounds? One ton = 2000 pounds.
3. The ash in the preceding problem consists of small particles and is somewhat like sand in the way it feels. It has no volume, and the utility company must find a way to dispense of it. The density of the ash is 110 pounds per cubic feet. Calculate the number of cubic feet of ash produced in one year.
4. The ash described in the proceeding problems is to be spread over some land that has no other uses. What area of land (in acres) would be required if the ash from one year of operation were spread
out in a layer one foot thick? 5. The life of a power plant is about forty years, so the plant described above could deposit a layer of ash forty feet thick over the area that you calculated in the preceding problem. Can you think of a good use for a hill made in this way?
6. To get a better idea of the size of the land covered in the preceding problem let's calculate the area in city blocks. A typical city block is a square 300 feet on a side. How many acres are there in a city block? How many city blocks would be covered by the layer of ash calculated in the preceding problem?
7. Suppose that a city block has this shape:

(figure available in print form)

320 feet 280 feet
300 feet

How many square feet are there in this block? How many acres?

8. A Datsun 280Z has a turning radius of 4.5 feet. If this car is driven in a tight circle, how far does it go in one complete turn?

9. Danny discovered four different coal mines, following are the shapes of the mines, find the perimeter of each.

(figure available in print form)

The following are topics that students may use to create their own word Problems.

OTHER TOPICS AND PROBLEMS

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10 speed bicycle
Energy work, and power
    Climbing stairs and hills
    Hydroelectric power
    Exercise physiology and athletics
Probability
    Flipping coins
    Drawing cards
    Baseball statistics
General of electricity
    Volume and density calculations (coal pile, ash, scrubber sludge)
    Cooling water rates
    Conversion of heat to electricity
    Simple chemical calculations

(figure available in print form)

Appendix A

(figure available in print form)

Appendix B

(figure available in print form)

Appendix C

(figure available in print form)

Appendix D

(figure available in print form)

Appendix E

(figure available in print form)

Appendix F

(figure available in print form)

Appendix G

Quiz #1

(figure available in print form)

Quiz #2

(figure available in print form)

Quiz #3

(figure available in print form)

Quiz #4

(figure available in print form)

Quiz #5

(figure available in print form)

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QUIZZES 1-5 National Coal Association

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