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ABSTRACT

The guide, the product of an exemplary career education program for junior high school students, was developed to show how geometry can be applied to real-life career-oriented areas and to bring a practical approach to the teaching of geometry. It is designed to show how some of the theorems or postulates in geometry are used in different careers. The guide lists each of 44 postulates or theorems with an appropriate figure, explains it, and presents its possible applications to the world of work. (Author/JR)

CAREER EDUCATION

GEOMETRY

CAREER UNIT

JUNIOR HIGH

A CAREER DEVELOPMENTAL PROGRAM

CAREER AWARENESS
SELF AWARENESS
APPRECIATION & ATTITUDES
DECISION MAKING
SKILL AWARENESS, BEGINNING COMPETENCE
ECONOMIC AWARENESS
EMPLOYABILITY SKILLS
EDUCATIONAL AWARENESS

White Bear Lake
Public Schools

GEOMETRY

CAREER UNIT

JUNIOR HIGH

by

Daniel Jensen

CAREER DEVELOPMENT

Grades 7 - 9

An Exemplary Program
in
Career Education

Funded under the Provisions of Part D
of the Vocational Education Amendment of 1968

Independent School District #624
White Bear Lake, Minnesota

Ernest M. Thomsen, Superintendent
Ron Johnstone, Director Vocational Education

1972 - 73

INDEX

INDEX

-Continued-

INDEX

-Continued-

INTRODUCTION

This project was developed to show how Geometry could be applied to real life career oriented areas and to help bring a practical approach to the teaching of Geometry. It is to be used by the teacher as a guide to show how some of the theorems or postulates in Geometry are used in different careers.

Interviews with persons who were actually involved in certain jobs showed how the theorems or postulates were used. Also, I wish to thank Mr. David Dye, Minnesota Mathematics Consultant, for his suggestions and help. I would suggest that the reader obtain the booklet, Geometry-Career Related Units, a joint project between the Minnesota State Department of Vocational Education and the Robbinsdale Area Schools, as this proved very beneficial to me.

Objectives for this project could vary depending on the user's needs; however, here are some that could be used.

1) The student will explore areas of interest in work roles relative to different careers.

2) The student will become aware that priorities, values and goals are modified throughout life.

3) The student will explore problem solving relating to different careers.

4) The student will have to analyze, organize, and solve problems relating to different careers using geometry concepts as well as other mathematical skills.

POSTULATE: Two points determine a line.

A) Used in:
   1) concrete work (leveling it off).
   2) building (see if a board is straight).
   3) sighting with a gun.
   4) carpenter's chalk line.
   5) determining boundary lines.

RULER POSTULATE: The points of a line can be placed in correspondence with the real numbers in such a way that:

- to every point of the line there corresponds exactly one real number,

- to every real number there corresponds exactly one point of the line, and

- the distance between two points equals the absolute value of the difference between the corresponding numbers.

A) Used in:
   1) measuring with a broken ruler.
   2) measuring distance between points for curtain rods.
   3) measuring in a corner or a tight spot, turn it around and measure.

POINT-PLOTTING THEOREM: Let $\overrightarrow{AB}$ be a ray and let x be a positive number. Then there is exactly one point P of $\overrightarrow{AB}$ such that AP = x.

A) Used in building.
   1) placement of studs, etc.

MIDPOINT THEOREM: Every segment has exactly one midpoint.

A) Used in:
   1) dividing a piece of ribbon or cloth.
   2) teeter totter.
   3) balance point.
   4) pie crust.

THEOREM: If two lines intersect, then their intersection contains exactly one point.

A) Used in:
1) finding a fishing spot.
2) finding center of room for tiling.

POSTULATE: Every plane contains at least three noncollinear points.

A) Used in:
1) suspended grid work for a ceiling.

POSTULATE: If a plane contains two points of a line, the plane contains the whole line.

A) Used in:
1) suspended grid work for a ceiling.

POSTULATE: Any three points lie in at least one plane, and any three collinear points lie in exactly one plane.

A) Used in:
1) three legged stool
2) tripod
3) transit
4) tricycle wheels

POSTULATE: Angle Construction Postulate. Let $\overrightarrow{AB}$ be a ray contained in the edge of a half-plane H. For each number r between 0 and 180, there is exactly one ray $\overrightarrow{AP}$, with P in H, such that $m < PAB = r$.

A) Used in:
1) construction of a house (right angles).
2) building hexagonal or octagonal tables.

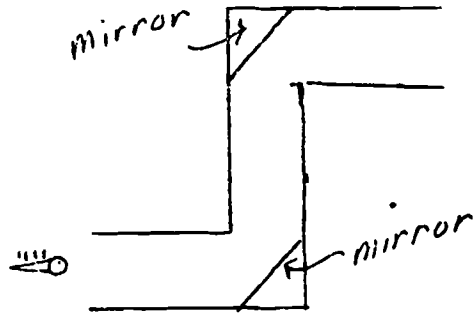
CONGRUENT ANGLES

A) Physicists tell us that a ray of light which strikes a mirror is reflected at the same angle at which it arrives.

$\angle a \cong \angle b$

CONGRUENT ANGLES--Continued

B) The drawing below illustrates a simple periscope. Explain how it works.



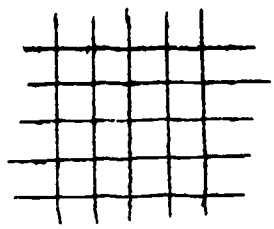
TRIANGLES

A) Used in construction for rigidity.
   1) braces
   2) rafters
   3) cross pieces in a gate

B) Used in home planning.
   (See State Department of Education Booklet on Geometry)

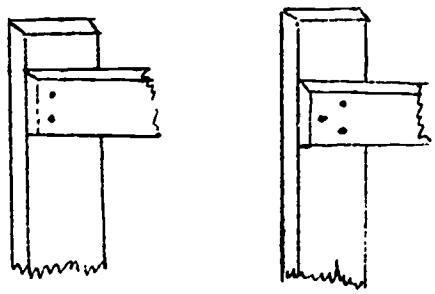
DEFINITION OF A TRIANGLE

A) Uses of triangles.
   1) A garden lattice is constructed as shown.



What could be done to prevent this lattice from collapsing?

2) Which of the two pieces of lumber illustrated is nailed securely and why?

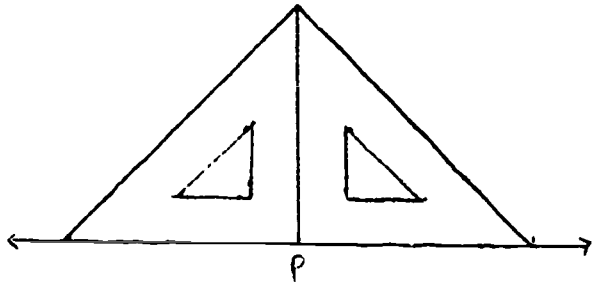


THEOREM: If two angles are both congruent and supplementary, then each of them is a right angle.

THEOREM: Given a plane, a line in the plane, and a point on the line, there is exactly one line that is in the given plane, contains the given point and is perpendicular to the given line.

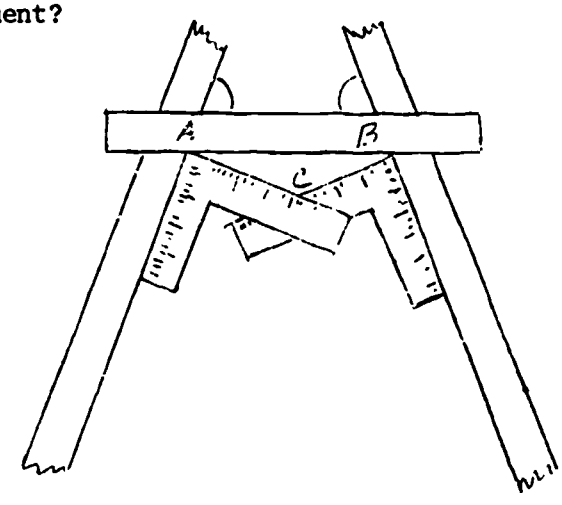
A) Used in drafting.
   1) To check the right angle on a plastic triangle, a draftsman will sometimes do the following:
      a) place his triangle on the right as shown and draw a perpindicular at P.
      b) place his triangle on the left and draw a perpindicular at P.

   Explain why this method is a check.



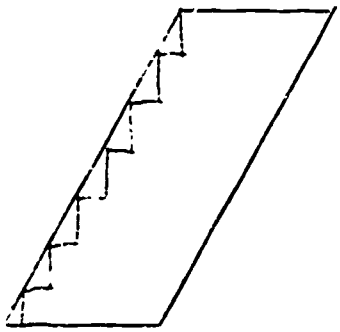
THEOREM: Complements of congruent angles are congruent.

A) A carpenter wishes to brace two beams at A and B and make congruent angles with them. He places two carpenter's squares as shown so that AC = BC. Why are the angles congruent?



SAS POSTULATE

A) Used in carpentry
   1) Cutting treads in stair risers

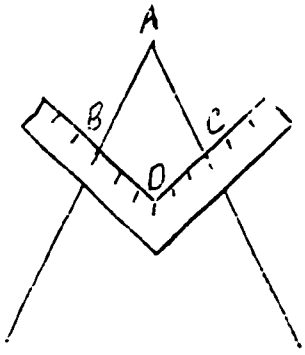


THEOREM ASA

The story is told that during one of Napoleon's marches his troops were forced to cross a river of an unknown width. It is said that one of his officers determined the width using the following method. The officer sighted the opposite bank of the river by pulling the visor of his cap down to meet his line of vision. Remaining at the same spot he sighted along the bank of the river until his eyes rested on a point in line with his visor. He paced off the distance along the bank to this point and claimed that this was the width of the river. What geometry theorem did he use? Explain.....

THEOREM SSS

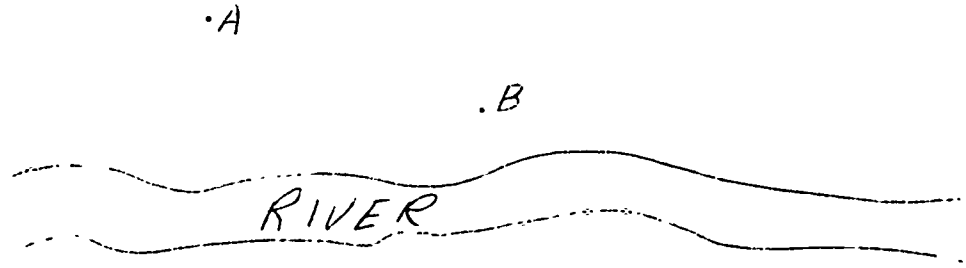
A) Used in carpentry
   1) A carpenter may use the following method to bisect an angle at the corner of the board. Along the edges he will mark equal length AB and AC. He then puts his square on the board so that the sides contain B and C and BD = CD. He then makes a mark at D and draws $\overline{AD}$. Why does AD bisect $\angle$ BAC?



ISOSCELES TRIANGLE: If two sides of a triangle are congruent, then the angles opposite these sides are congruent.

A) Used in:
   1) why clothes hangers are made the way they are.

PERPENDICULAR BISECTOR THEOREM: Two factories A and B, are situated near a river and they agree to use the same dock. Where should the dock be constructed so that it will be the same distance from each factory.

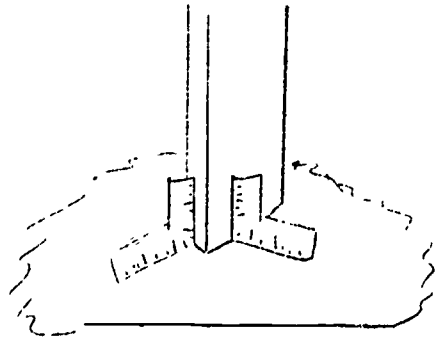


THEOREM: If two lines in the same plane are both perpendicular to the same line, then they are parallel.

A) Used in:
   1) building rafters
   2) building studs

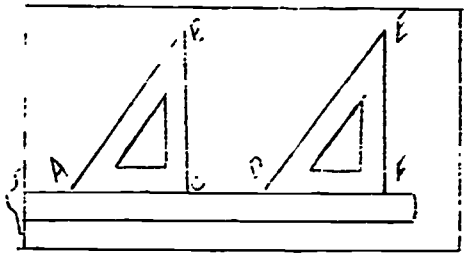
THEOREM: If a line is perpendicular to each of two intersecting lines at their point of intersection, then it is perpendicular to the plane containing them.

A) Why does a carpenter perform the illustrated experiment to check to see if the stud and the floor are perpendicular? (What theorem is used?)



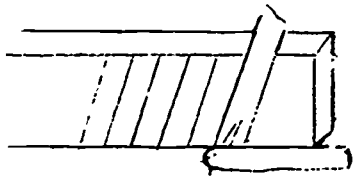
THEOREM: Two lines perpendicular to the same line are parallel.

A) Used in drafting,
   1) A draftsman draws parallel segment by using a T-square and a plastic triangle. He places his T-square along $\overline{AC}$ and then he puts his triangle on the T-square as shown below. He then draws $\overline{BC}$. Next he moves the triangle along the T-square to a new position and draws $\overline{EF}$. Why is $\overline{BC} \parallel \overline{EF}$?



THEOREM: If two lines are cut by a transversal so that a pair of corresponding angles are congruent then the two lines are parallel.

A) Used in carpentry.
   1) A carpenter uses an instrument called a bevel. What theorem is involved in drawing parallel cutting lines as shown?



THEOREM: The diagonals of a rectangle are congruent.

A) Used in:
   1) checking to see if a basement is in shape of a rectangle.
   2) laying out of a track to see if the inner part is in a rectangle.
   3) laying out of a football field.

THEOREM: Parallel planes are everywhere equidistant.

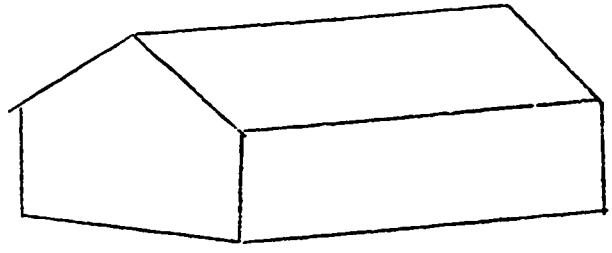
A) Used in handyman's construction.
   1) Bookshelves
   2) Kitchen cabinets

THEOREM: Two lines perpendicular to the same plane are parallel.

A) Used in:
   1) goal posts in football.
   2) studs in building.
   3) fence posts.

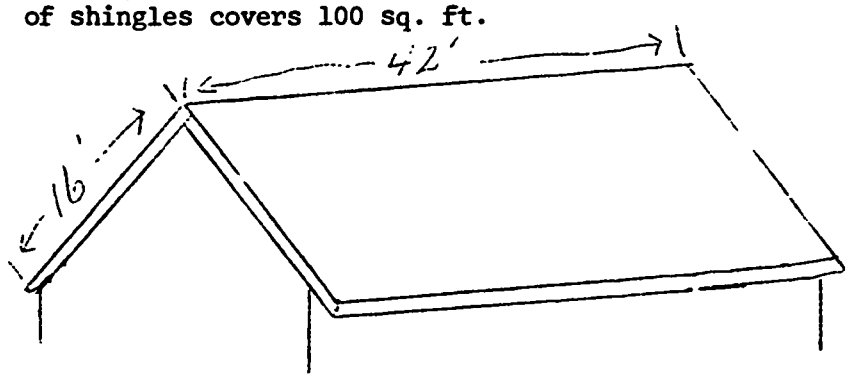
AREA ADDITION POSTULATE: If a polygonal region R is the union of non-overlapping polygonal regions R_1 and R_2, then $\mathcal{A}(R) = \mathcal{A}(R_1) + \mathcal{A}(R_2)$.

A) Used in painting.
   1) Find the number of gallons of paint needed to paint a house 26' x 45' and the highest point is 20' from the ground. (Each gallon covers approximately 400 sq. feet.) How is area addition postulate used?



B) Used in wallpapering a room.
   1) Joan is going to wallpaper her bedroom. How many rolls of wallpaper should she order if her room is 13' X 11' and 8' high. (Single roll of wallpaper covers 70 sq. ft.)

C) Used in shingling.
   1) Both sides of a roof must be shingled. Find out how many squares of shingles he should order if 1 square of shingles covers 100 sq. ft.

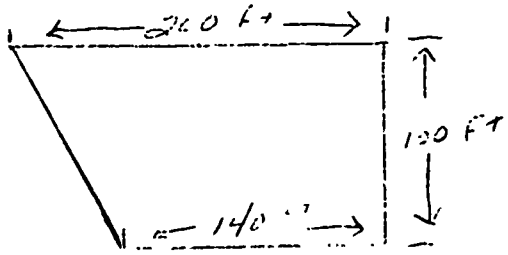


THEOREM: Areas of triangles, squares.

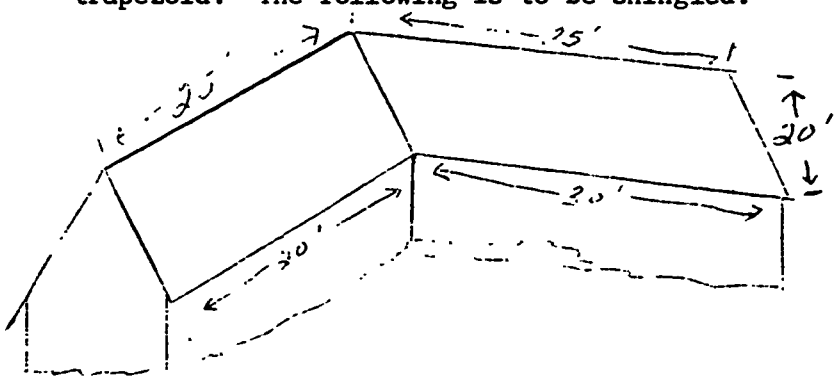
A) Used in:
   1) painting.
   2) shingling.
   3) landscaping
   4) fertilizing
   5) sodding.
   6) making driveways.
   7) making sidewalks.

THEOREM: Area of a trapezoid

A) Used in landscape.
   1) You are to fertilize the field pictured below by applying three pounds of nitrogen per 1,000 square feet. Fertilizer cost $.55 a pound and the analysis is 24-16-12. How much will the fertilizer cost? What does the analysis 24-16-12 mean?



2) L-shaped houses have a roof in the shape of a trapezoid. The following is to be shingled.



If 100 sq. ft. = 1 square of shingles and if 1 square of shingles comes in three bundles, how many bundles must be ordered? If a roofer put them on for $5.00 a square, what will be the cost?

ISOSCELES RIGHT TRIANGLE THEOREM

A) Used in plumbing and pipefitting.
   1) Find the offset angle if the height is 5" and the run is also 5". Also find the length of pipe needed.

THEOREM: Area of a triangle. The area of a triangle region is half the product of the lengths of any base and the altitude to that base.

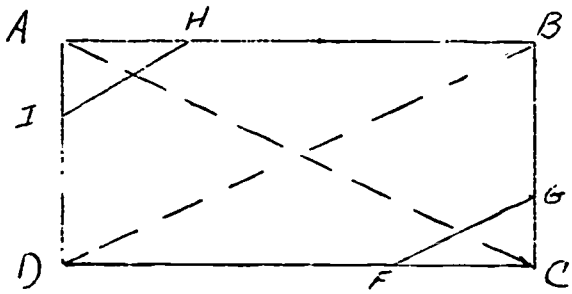
A) Used in construction.
   1) Another way to find the area of a triangle is by the formula $A = S(s-a)(s-b)(s-c)$ were $S = \frac{1}{2}(a+b+c)$ and a, b, c are the three sides of the triangle. A church is putting in a stained glass window that is in the shape of a triangle with sides 16', 18', and 18', and it cost $50 per square foot. Find the cost.

THEOREM: Pythagorean theorem.

A) Used in navigation
   1) To find the distance if a plane is being blown off course.

B) Used in carpentry,

1) Rectangle ABCD represents the lines of excavation for the foundation of a building. Find the length of the diagonals if AB = 25' - 0" and AD = 60'0".



AC =

BD =

Another way to check to see if corner C is square would be to lay off $\overline{CG}$ = 3'0" and CF = 4'0". What should the length of $\overline{GF}$ equal?

To square corner A, we lay off $\overline{AH}$ = 6' 0" and AI = 8' 0". What is the length of $\overline{HI}$?

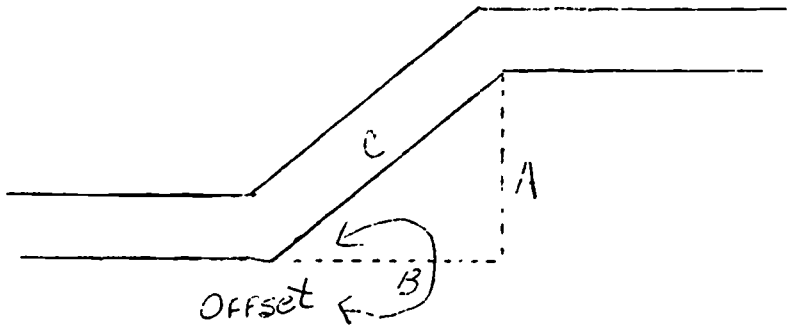
C) Used in sports.

1) Laying out a baseball diamond.

30 - 60 TRIANGLE THEOREM: In a right triangle, the hypotenuse is twice as long as a leg if and only if the measure of the angle opposite that leg is 30.

A) Used in plumbing and pipefitting.

1) Common offset angles in plumbing and pipefitting are 30°, 45°, and 60°.



A plumber must adjust his run so that A = 10" and the offset $\measuredangle$ is 30°. Find the length of C and B.

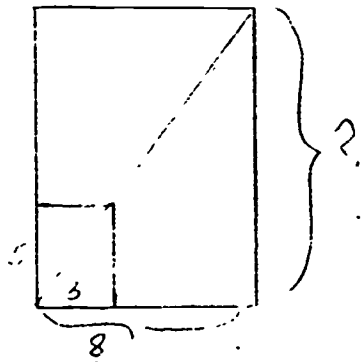
PROPORTIONS

A) Used in design and fashions.
   1) See State Department of Education Book on Geometry

B) Used in blueprints.

THEOREM: AA $\sim$

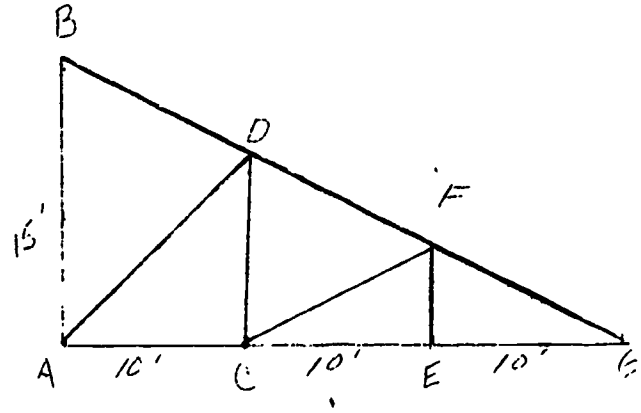
A) Used in printing and graphic arts
   1) Enlargement or reduction of a picture.



A 3" by 5" picture is to be enlarged to an 8" wide copy. Find the length of the missing side.

B) Used in engineering.
   1) In building a bridge, similar triangles are used. In the figure, $\overline{AB}$, $\overline{CD}$, and $\overline{EF}$ are perpendicular to $\overline{AG}$. Find the dimensions of the following:

   a) DC =
   b) EF =
   c) AD =
   d) CF =
   e) BG =



C) Used in forestry.

1) Two forest lookout stations, 4 miles apart, observe a fire. The observer at one of the stations finds the measure between the other station and the fire is 72°. The other observer finds the $\angle$ to be 50°. How far is the fire from each lookout to the nearest tenth of a mile. (You will have to use a ruler and protractor to construct a scale drawing.)

2) How high is a tree if it casts a shadow of 36' when a man 6' tall casts a shadow of 10'?

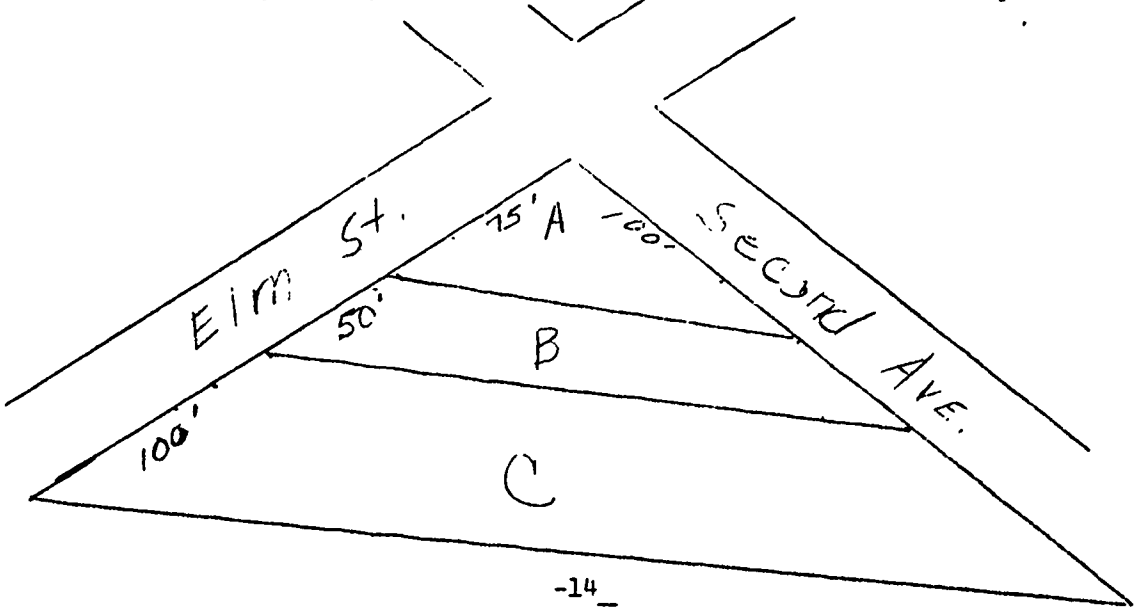
THEOREM: SAS Similarity.

THEOREM: If two lines are cut by a transversal so that a pair of alternate interior angles are congruent, then the two lines are parallel.

A) Explain why an ironing board can be adjusted and always have the board remain parallel to the floor

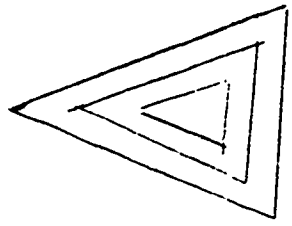
THEOREM: If three parallel lines are cut by two transversals, then the length of the segments intercepted on one transversal are proportional to the lengths of the corresponding segments intercepted on the other transversal.

A) When a storm sewer is put in your community, you are assessed by the square footage of your lot. If the assessment is 5¢ a square foot, figure out the cost for each property owner A, B & C. (Assume the lines are parallel.)



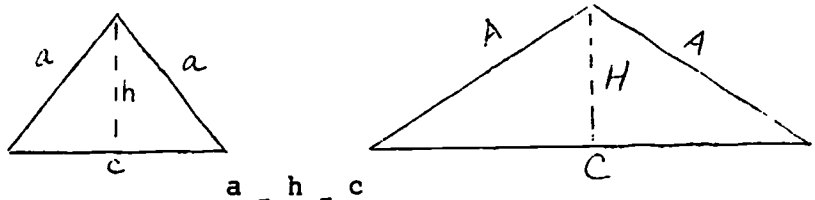
SIMILAR FIGURES

A) Used in drafting and architecture.
B) Used in blueprints.
C) Layers of triangular pyramids in construction. (design)



Top View

D) Art work (designs)
E) Model making
F) Building an A-frame house
G) Rafter design of house and garage are to be the same.

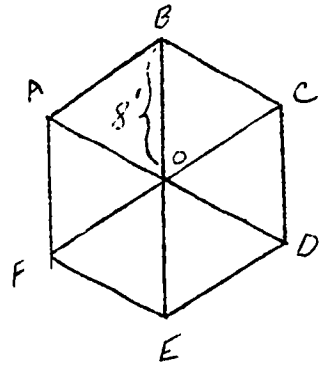


$$\frac{a}{A} = \frac{h}{H} = \frac{c}{C}$$

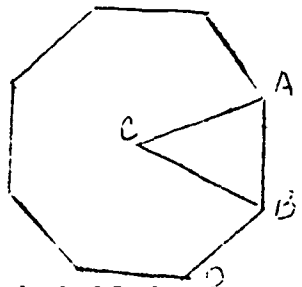
H) If in covering buttons on a dress with plaid or checked material, the diameter of the button is perpendicular to a line in the material then all buttons will be similar.

ANGLE MEASUREMENT OF A POLYGON

A) Used in making tables and patios.
   1) If a hexagonal patio with redwood spokes is desired
      a) find m < OAB
      b) find AB
      c) find $\measuredangle_{\Delta}$ OBA
      d) find area of hexagon
      e) what is the cost to make it out of concrete, if concrete costs $27.00 a cubic yard and they need it 4" thick?



2) If Bruce is going to build an octagonal table what is the measure of
   a) m < ABC =
   b) m < ABD =
   c) m < ACB =



THEOREM: The measure of an inscribed angle is half the measure of its intercepted arc.

A) Used in:
   1) surveying
   2) navigation

CONGRUENT CENTRAL ANGLES GIVE CONGRUENT ARCS

A) Used in art and design.
B) Used by machinist to locate where bolt holes are placed on a circular wheel.

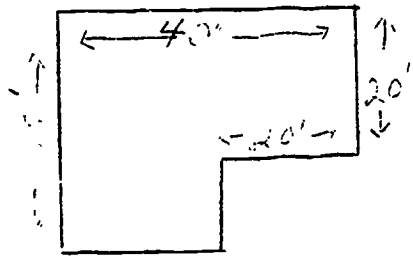
THEOREM: $A = \pi r^2$

A) Plumbing and pipefitting
   1) Plumbers and pipefitters must have an understanding of the carrying capacity of different size pipes. A 6" water pipe can carry how many times as much water as a 2" pipe? (Make a quick guess.)_____ To solve this problem you need to find the areas of the ends of each pipe.
      Area of 2" pipe =_____
      Area of 6" pipe =_____
      How much more water will a 6" pipe carry than a 2" pipe?
   2) Two separate pipes have been used to carry drainage from the second floor of an apartment building. If the diameters are 3" and 4", find the diameter of a single pipe having the same carrying capacity.

POSTULATE: Volume of a rectangular prism.

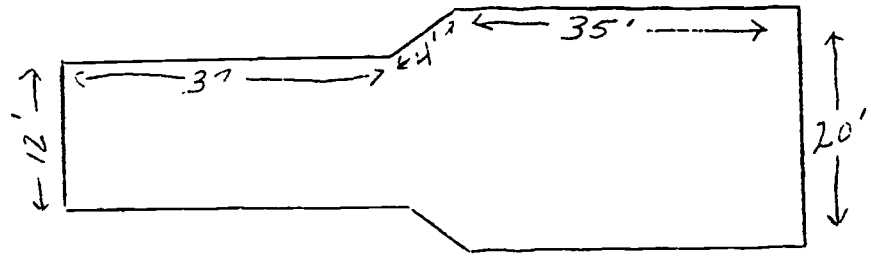
A) Used by a general contractor.

1) The basement for an L-shaped house must be excavated to a depth of 8'. At $1.50 per cubic yard, find the cost of excavating the basement.



2) If a lot 80' by 120' had to be raised 6", find the cost if fill costs $1.10 per cubic yard.

3) This past summer I put in a concrete driveway. I had to hire a contractor to dig it to an 8" depth to allow for 4" of sand to be hauled in and 4" of concrete. I was informed that the cost to dig it out was about $5.00 per cubic yard. Sand cost $5.00 per cubic yard and concrete cost $25.00 per cubic yard. What did it cost me to put in my driveway.



4) If you had to replace your back (or front) steps how much concrete would you have to order? Draw a scale drawing of your steps also.

5) If the sidewalks had to be replaced at your house, how much concrete would you have to order? (Make the sidewalks 4" thick.) Draw a scale drawing of your sidewalks also.