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**A Comparison of Two Methods of Teaching Mathematics:
Manipulative and Conventional.**

Richard B. Atwood

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A Comparison of
Two Methods of Teaching Mathematics:
Manipulative and Conventional

Presented to the
Department of Teacher Education
and the
Faculty of the Graduate College
University of Nebraska

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts in Education

University of Nebraska at Omaha

by

Richard B. Atwood

May 1991

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THESIS ACCEPTANCE

Acceptance for the Graduate Faculty, University of Nebraska, in partial fulfillment of the requirements for the degree Master of Arts in Education, University of Nebraska at Omaha.

Supervisory Committee

Name

Department

Sandra K. Squires

Special Education & Com. Disorders

Helen Howell

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Chairman

4-16-91

Date

Abstract

This study was designed to provide information on the use of manipulatives in an elementary school mathematics curriculum. The primary goal was to determine if there was a significant difference in student achievement in mathematics at the third grade level when selected mathematics concepts are taught through the use of manipulatives compared to the use of conventional textbooks and worksheets.

The sample in this study consisted of one third grade class from a small school in a community of approximately six thousand people. This class of twenty-four students, eleven girls and thirteen boys was taught by the researcher.

The class was divided into two matched groups based on information from a standardized achievement test and a textbook pretest over selected math concepts. The experimental group used manipulatives to master the lesson objectives. The control group used the conventional textbook and worksheet pages to master the lesson objectives. A post test published by the Heath Mathematics Company was administered to both groups to see if there was a significant difference in student achievement.

Analysis of the data through use of a t-test showed a significant difference to the .001 level of confidence in student achievement in third grade mathematics with the

experimental group producing higher scores than the control group. The findings from this limited study support the use of manipulatives as a supplement to the third grade mathematics curriculum.

ACKNOWLEDGEMENTS

The researcher wishes to acknowledge the following:

- My wife -- Camille, for her love, understanding and continued encouragement during graduate school and in my preparation of this thesis
- My father -- Robert W. Atwood, for his encouragement and understanding for my total educational career and for sharing his thirty-five years of experience as an Elementary School Principal with me
- My advisor -- Dr. Kaye Parnell, for her assistance in graduate school
- My Committee -- Dr. Kaye Parnell, Dr. Helen Howell, and Dr. Sandra Squires, for their time and suggestions
- My Principal -- Mrs. Cheryl Blue, for her time, suggestions and continued support in completing this project

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CHAPTER ONE

Introduction

The quality of the educational system in the United States has been closely scrutinized by the public during the past decade. Although much of the attention has been directed at secondary and postsecondary education, those who teach elementary education also should examine certain teaching practices in view of current knowledge of child development and learning. Appropriate practices should allow children to learn through concrete, play-oriented approaches involving the use of manipulatives.

The conventional approach to educating children today frequently includes the use of textbooks and accompanying workbooks or worksheets. Even in a content area such as elementary mathematics where concrete items seem most appropriate, the conventional mathematics curriculum makes minimal use of manipulatives. All students, regardless of ability, are placed in the same textbook and all do the same worksheets.

The mathematics curriculum packages which major publishing companies offer to elementary schools usually contain textbooks and workbooks or worksheets which are consumable and therefore must be replaced every year. Few manipulatives are available from their catalogues. However, mathematics educators in teacher education programs across

the country maintain that in order to understand mathematics children must have opportunities to manipulate concrete materials. Many teachers supply these missing parts of the curriculum by ordering from various school supply companies because they have found that manipulatives enhance the learning environment of each student. Some teachers believe publishing companies should provide manipulatives for the school curriculum in order to agree with current information about how young children learn.

Statement of the Problem

Is there a significant difference in student achievement in mathematics at the third grade level when selected concepts in mathematics are taught through the use of manipulatives compared to the use of conventional textbooks and worksheets?

Hypothesis to be Tested

There is no significant difference in student achievement in mathematics at the third grade level when selected mathematics concepts are taught through the use of manipulatives compared to the use of conventional textbooks and worksheets.

Significance of the Problem

The teaching of mathematics through the use of manipulatives is a practice which many educators support. However, there are still many class rooms in which pencil

and paper exercises predominate. This study is designed to compare the two approaches to teaching third grade mathematics.

Limitations

Limitation 1. The students selected for this study came from one elementary school classroom in one community.

Limitation 2. The researcher for this study was the regular teacher of the classroom.

Limitation 3. Students in the control group remained in the regular classroom for mathematics instruction during this study. The experimental group was moved to the cafeteria which was next door to the regular classroom. It is possible that being in a different environment for mathematics instruction had some effect on students' performance.

Definition of Terms

1. Basic Worksheets. A series of mathematics worksheets published by Heath Book Company.

2. Manipulatives. A variety of concrete materials which children use to illustrate specific mathematics concepts.

3. Conventional Methods of Teaching. Methods involving worksheets and other printed pages.

CHAPTER TWO

Review of Related Research

The current trend toward examination of the educational system in this country has recently included concerns about the quality of education provided in the elementary schools (Bennett, 1986; Office of Educational Research and Improvement, 1986). In response to calls for "back to the basics" and improved standardized test scores, numerous elementary schools have narrowed the curriculum and adopted instructional approaches that are incompatible with current information about how young children learn and develop. The narrowed curriculum and questionable instructional approaches have raised concerns from a variety of sources.

The National Association for the Education of Young Children (NAEYC), the largest organization of early childhood educators in the nation, defines early childhood as the years from birth through age eight/third grade. This organization believes that

". . . a high quality early childhood program provides a safe and nurturing environment that promotes the physical, social, emotional, and cognitive development of young children. . . . Although the quality of an early childhood program may be affected by many factors, a major determinant of program quality is the extent to which knowledge of child development is applied in program practices--the degree to which the program is developmentally appropriate" Bredekamp, (1987, p.1).

Developmentally appropriate practices are those which match the learning environment with the developmental level of each child. Bredekamp (1987) makes these specific recommendations for the mathematics curriculum:

"The goal of the math program is to enable children to use math through exploration, discovery, and solving meaningful problems. Math activities are integrated with other relevant projects, such as science and social studies. Math skills are acquired through spontaneous play, projects, and situations of daily living. Teachers use the teacher's edition of the math textbook as a guide to structure learning situations and to stimulate ideas about interesting math projects. Many math manipulatives are provided and used. Interesting board and card, paper-and-pencil, and other kinds of games are used daily. Noncompetitive, impromptu oral "math stumper" and number games are played for practice" (p.71).

Support for this approach to instruction in mathematics comes from recommendations by child development specialists, mathematics educators and others who have investigated the teaching/learning process rather than from empirical research studies (Bredekamp, p.81). The use of manipulatives for instruction in mathematics appears to be a widely recommended approach which has come to be accepted as common practice. A computer search for current research comparing manipulative use with other approaches in mathematics instruction yielded no results.

A review of the literature does indicate strong support for the use of supplemental manipulatives in various math

programs. These programs range from the preschool level through secondary school.

In a presentation given at the annual conference of the Southern Association on Children Under Six, Miller (1984) reported on the use of manipulatives at the pre-primary level. According to Miller, manipulatives for preschool programs should be carefully selected according to several criteria including attractiveness, simplicity, versatility, safety, and economy. Miller maintained that the use of manipulatives at the pre-primary level was extremely important.

Two-hundred-twenty teachers in grades one through three in eleven southwestern states were surveyed on their use of manipulatives for teaching mathematics (Gilbert and Bush, 1988). The results indicated that some common manipulative materials such as Unifix cubes, Cuisenaire rods, cubical wooden blocks, measuring sticks, abacuses, and weighing instruments were listed as "never used" by seventy-four percent of the teachers surveyed.

In a 1989 publication, Shefte suggested ways of using children's intuitive ideas about mathematics as a starting point for an elementary curriculum. Included were recommendations for using manipulatives such as cubical blocks, plastic money, rulers and metersticks, place-value

pocket charts, Cuisenaire rods and liquid measuring devices to demonstrate certain relationships in mathematics.

The Mississippi Department of Education compiled a document that contained teaching modules based on seventeen objectives for third grade mathematics. Each module included a list of necessary manipulatives such as cubical blocks, Unifix cubes, Cuisenaire rods, rulers, metersticks, balance scales, paper bills and plastic coins (Lynchard, 1989).

At the Nebraska Department of Education, Egertson (1989) compiled a listing of early childhood books dealing with the use of manipulatives in primary grades. Several books were endorsed by the State Board of Education in April, 1989 and were recommended for use in program development and improvement (Appendix A).

In Florida, Yeatts (1989) developed a program which was designed to increase the availability and use of manipulatives for mathematics activities in kindergarten, first and second grade classes. This program included information on ordering manipulatives, applying manipulatives to fit unit objectives, time management involving the use of manipulatives and setting up centers using manipulatives. A majority of the teachers who used this program indicated that it helped them gain

understanding and competence in integrating manipulatives into their regular course of mathematics instruction.

A manual produced by the National Council of Teachers of Mathematics provides teachers with a series of lessons on solving word problems through the use of manipulatives. Lessons one through seven lent themselves to modeling by having children act out each situation by using manipulatives. The use of manipulatives such as plastic money, cubical blocks, Unifix cubes, small plastic balls and other items was highly encouraged throughout this manual (Feinberg, 1988).

The Ohio State Department of Education (1988) created a mathematics program that describes goals, student outcomes, and instructional techniques for mathematics in the elementary and middle grades. Included were sections on the use of manipulatives in personalizing instruction.

The Louisiana Department of Education (1986) recognized the need to raise grade level expectations in mathematics for all children. A state curriculum guide was developed to bring about this result. An index to curriculum standards as well as a list of suggested manipulatives are provided in this guide.

Moser (1986) also described a mathematics curriculum centered on manipulative use. He recommended that manipulatives should be used by children of all ages and

stated that manipulatives are especially important in mathematics instruction. The specific kinds of manipulatives that should be used depend on the grade level and the complexity of each objective.

The National Council of Teachers of Mathematics in Virginia has made various recommendations for improving curriculum content in secondary education. Specific recommendations addressed the use of manipulatives in problem solving, expanding basic skills, using calculators, using computers, and other abstract operations of application (Hirsch, 1986).

The Alberta Department of Education (1988) designed a mathematics resource manual to enable secondary teachers of mathematics to help students solve problems. The use of appropriate manipulatives was also recommended for geometry, algebra, calculus, and other advanced classes in mathematics.

It appears from the review of related literature that the use of manipulatives is highly recommended in mathematics curricula ranging from the pre-primary grades through high school. It seems likely that the use of manipulatives in a third grade mathematics program would have a positive effect on student achievement.

CHAPTER THREE

Design of the Study

This study was conducted in a three week period during the second semester of the 1990-1991 school year.

The sample in this study consisted of one third grade class from a small elementary school in a community of approximately six thousand people. This class of twenty-four students, eleven girls and thirteen boys, was taught by the researcher. The children came from families ranging from low-average to high-average income status. Prior to the beginning of the study, a letter explaining the project was sent home with each student (Appendix B).

The study included fifteen lesson objectives. The student will:

1. measure with a centimeter ruler.
2. measure with a centimeter ruler, measure with a meterstick, and compare centimeters and meters.
3. find the perimeter of a figure in a standard unit of measurement.
4. find the area of a region by counting the centimeter squares inside the region.
5. find the volume of a rectangular solid by counting the number of centimeter cubes necessary to fill the solid.

6. choose reasonable estimates of weight using metric measures.
7. choose reasonable estimates of temperature using metric measure.
8. measure lengths using an inch ruler.
9. measure segments to the nearest half-inch.
10. measure lengths using inches, feet, and yards and make conversions between inches, feet, and yards.
11. determine the area of a figure by counting the inch squares that cover each figure and find the perimeter of a figure in a conventional unit of measurement.
12. determine the volume of a solid composed of one inch cubes by counting the cubes.
13. make conversions between cups, pints, quarts, and gallons.
14. determine weight by using conventional measures.
15. determine temperature using conventional measures.

The researcher formed two matched groups (Appendix G) in this third grade class by reviewing the Comprehensive Tests of Basic Skills mathematics scores from the previous year and the scores from a textbook pretest on the listed objectives (Appendix C).

During the study, the experimental group met in the cafeteria which was located next door to the regular

classroom. The control group remained in the regular classroom. When the researcher provided mathematics instruction to one group, the other group was involved in independent work in a different content area. Because of the proximity of the two rooms, the researcher was able to monitor both groups effectively.

The experimental group used the following manipulative materials in order to meet the objectives listed:

- a. Oaktag shapes of various figures
- b. Cubic centimeter
- c. Cubic inch blocks
- d. Balance scales with gram and conventional weights
- e. Various sized containers such as:
 - 1) cups
 - 2) pints
 - 3) quarts
 - 4) gallons
- f. Floor scales measuring both kilograms and pounds
- g. Several buckets of water
- h. Food coloring and stir sticks
- i. Geoboards
- j. Various materials, such as rulers and scales, with which to measure lengths and weights

The format for each lesson plan was as follows:

- 1) Anticipatory set - Focused the learner on what was

going to be taught. Prepared the student for learning.

- 2) Objective/Purpose - Stated the importance of the lesson.
- 3) Input - The main sector of the lesson. Explanation of the lesson through lecture and teacher use of manipulatives.
- 4) Modeling - Examples with use of manipulatives indicated to the students the concepts being taught.
- 5) Monitoring - Circulating around the room to see if the students understood what was taught.
- 6) Guided Practice - As students do examples using manipulatives the teacher checks to be sure they correctly demonstrate the concept.
- 7) Independent Practice - Students created their own assignments using manipulatives dealing with the lesson objective.

The control group used the following materials to accomplish the objectives listed:

- a. Basic worksheet papers
- b. Student textbooks
- c. Teacher textbooks
- d. Chalkboard and chalk
- e. Pencils and papers

The lesson plans for the control group followed the same seven step format used with the experimental group.

- 1) Anticipatory set - Focused the learner on what was going to be taught. Prepared the student for learning.
- 2) Objective/Purpose - Stated the importance of the lesson.
- 3) Input - The main sector of the lesson. Explanation of the lesson through lecture.
- 4) Modeling - Examples indicated to the students the concepts being taught.
- 5) Monitoring - Circulating around the room to see if the students understood what was taught.
- 6) Guided Practice - As students do examples on paper, the teacher checks to be sure they correctly demonstrate the concept.
- 7) Independent Practice - Basic worksheet assignment and other assignments were provided from the regular textbook (Appendix D).

A time block of three weeks was allotted for this study (Appendix E). Then, a post test developed by the Heath Mathematics Publishing Company was administered to both the experimental and the control group (Appendix F).

CHAPTER FOUR

Presentation and Analysis of Data

The mean scores of the experimental and control group were compared. This comparison between mean scores and standard deviation is displayed on Table 1.

TABLE 1

Math Post Test Scores

Group	Number in each group	Mean %	Standard Deviation	T-Test
Experimental Group (Manipulatives)	12	93	2.7386	3.5178 *
Control Group (Worksheets)	12	87.8	3.8971	

* A t-test of 3.52 would indicate that there was a significant difference $P < .001$.

The table shows the mean scores for the experimental and the control groups. After examining the Critical Values of Student's Distribution (t) Chart, the t-test score on this table indicates that the difference between the mean scores is significant at the .001 level.

CHAPTER FIVE

Summary and Conclusions

Restatement of the Problem

The primary purpose of the study was to find out if there was a significant difference in student achievement in mathematics at the third grade level when selected concepts in mathematics are taught through the use of manipulatives compared to the use of conventional textbooks and worksheets.

The hypothesis tested was: There is no significant difference in student achievement in mathematics at the third grade level when selected mathematics concepts are taught through the use of manipulatives compared to the use of conventional textbooks and worksheets.

Description of Procedure Used

The sample in this study consisted of one third grade class from a small elementary school. This class of twenty-four students was taught by the researcher. The class was divided into two matched groups for instruction in mathematics. The experimental group participated in the math unit by using only manipulatives. The control group participated in the math unit by using conventional printed textbook and worksheet pages. A standard textbook post test was administered to both groups to determine if a significant difference in student achievement existed.

Principal Findings and Conclusions

The results of this study reject the null hypothesis. The mean post test score of students in the experimental group was significantly higher ($p < .001$) than that of students in the control group. It would appear that the control group may have had a slight advantage in this study because these students had mathematics instruction in their usual environment. The experimental group, on the other hand, was moved to the cafeteria for mathematics instruction. In spite of this change in usual procedure, the experimental group's average scores were significantly higher than the control group's scores. This finding clearly supports the use of manipulatives in teaching selected concepts in mathematics at the third grade level.

Recommendations for Future Research

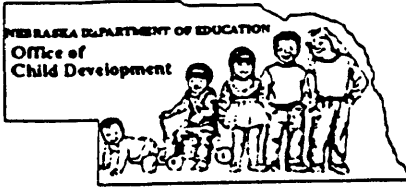
Future investigations in this area could focus on the role of manipulatives in middle or secondary school mathematics programs or identifying and matching specific concepts with the most appropriate manipulative materials. Student attitudes toward mathematics when it is taught with manipulatives versus pencil and paper exercises could also be investigated.

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- Shefte, A. (1989). The Application of Childrens' Mathematical Institution to an Elementary Curriculum. Los Angeles: University of Southern California.
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Appendix A
Kindergarten/Primary
Program Resources



KINDERGARTEN/PRIMARY PROGRAM RESOURCES

- * Bredekamp, S. (Ed.). (1987). Developmentally Appropriate Practice in Early Childhood Programs Serving Children Birth Through Age 8. Washington, DC: National Association for the Education of Young Children. 800/424-2460.

- British Columbia Ministry of Education. (1990). Primary Programs Foundation Document and Resource Document. Victoria, BC: Author. 604/356-7541.

- Katz, L.G., Evangelou, D., and Hartman, J.A. (1990). The Case for Mixed-Age Grouping in Early Childhood Education Programs. Washington, DC: National Association for the Education of Young Children. 800/424-2460.

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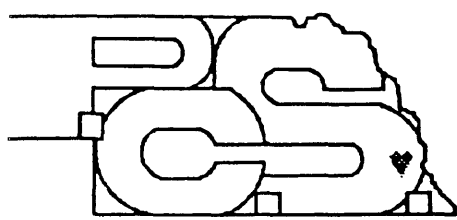
- Wasserman, S. (1990). Serious Players in the Primary Grades: Empowering Children Through Active Learning Experiences. New York, NY: Teachers College Press.

- * These documents were endorsed by the State Board of Education in April, 1989, and are thereby recommended for use in program development and improvement.

- (If you have any questions about how to obtain these materials or other questions about early care and education, please contact Harriet A. Egertson, Office of Child Development, Nebraska Department of Education, 301 Centennial Mall South, Lincoln, NE 68509; 402/471-3184.)

Appendix B

Parent Information Letter



Plattsmouth High School
724 8th Avenue
Plattsmouth, NE 68048
96-3323

Plattsmouth Middle School
10th and Main
Plattsmouth, NE 68048
96-3174

Central School
10th and Main
Plattsmouth, NE 68048
96-4173

Columbian School
10th Avenue
Plattsmouth, NE 68048
96-4270

First Ward School
602 Avenue D
Plattsmouth, NE 68048
96-3193

Lincoln School
17th and Lincoln Av.
Plattsmouth, NE 68048
96-4259

Wintersteen/Headstart
South 1st Street
Plattsmouth, NE 68048
96-5250

Central Elementary School
Plattsmouth, Nebraska

Dear Parents,

During the month of February, our class will be involved in a research project during mathematic sessions. The class will be divided into two groups that will each receive a different kind of instruction. One group will be working with manipulatives, while the other group will be focusing on worksheets and other various assignments.

During this study, which should last about fifteen days, it is highly recommended that your child receive an adequate breakfast consisting of a cereal with milk, toast, and orange juice. A school breakfast is offered for students who do not eat at home.

Thank you for your cooperation in this matter.

Sincerely,

Richard Atwood

Please sign and return with your child.

Parent's Signature

Appendix C
Heath Mathematics
Pretest

Chapter 9 Pretest

Name _____

Part A Metric system

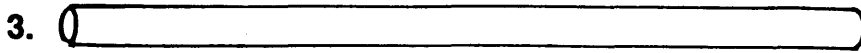
Measure with a centimeter ruler. [Obj. 9-1, pages 242-245]



_____ cm

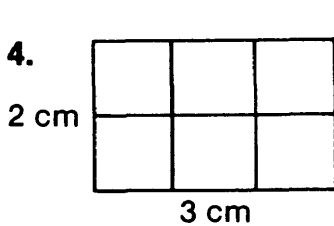


_____ cm

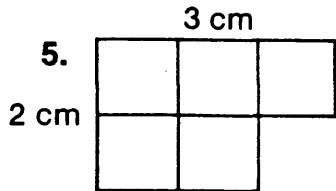


_____ cm

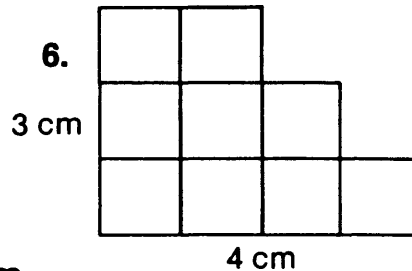
Give the perimeter. [Obj. 9-2, pages 246-247]



_____ cm



_____ cm



4 cm

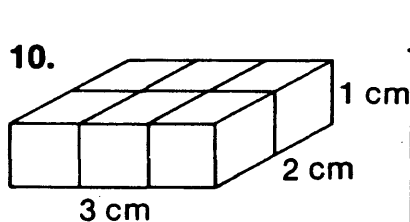
Give the area of each figure above. [Obj. 9-3, pages 248-249]

7. _____ square cm

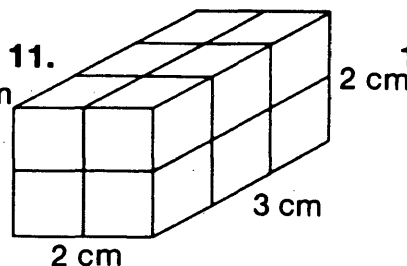
8. _____ square cm

9. _____ square cm

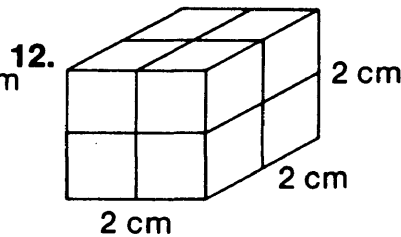
Give each volume. [Obj. 9-4, page 250]



_____ cubic cm



_____ cubic cm



_____ cubic cm

Choose the answer that seems right. [Obj. 9-5, pages 251-252]



1 liter or 10 liters

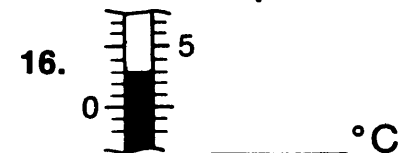


1 g or 1 kg

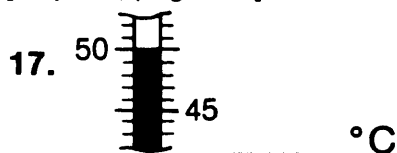


2 g or 2 kg

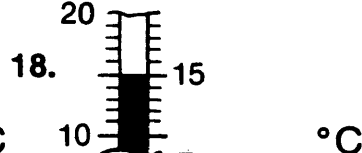
Give each temperature. [Obj. 9-6, page 253]



_____ °C



_____ °C



_____ °C

Answers

- 1. _____
- 2. _____
- 3. _____
- 4. _____
- 5. _____
- 6. _____
- 7. _____
- 8. _____
- 9. _____
- 10. _____
- 11. _____
- 12. _____
- 13. _____
- 14. _____
- 15. _____
- 16. _____
- 17. _____
- 18. _____

Chapter 9 Pretest

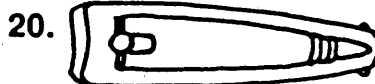
Name _____

Answers

(continued)

Part B Customary system

Measure with a half-inch ruler. [Obj. 9-7, pages 254-259]



_____ in.

_____ in.

19. _____

20. _____

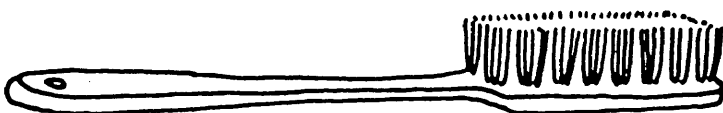
21. _____

22. _____

23. _____

24. _____

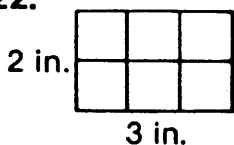
21.



_____ in.

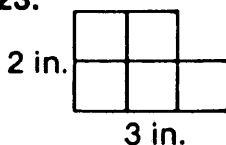
Give the perimeter. [Obj. 9-2, pages 260-261]

22.



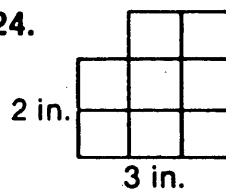
_____ in.

23.



_____ in.

24.



_____ in.

25. _____

26. _____

27. _____

28. _____

29. _____

30. _____

Give the area of each figure above. [Obj. 9-3, pages 260-261]

25. _____ square in.

26. _____ square in.

27. _____ square in.

31. _____

32. _____

33. _____

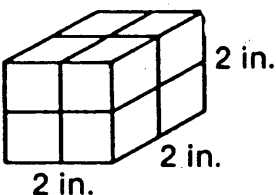
34. _____

35. _____

36. _____

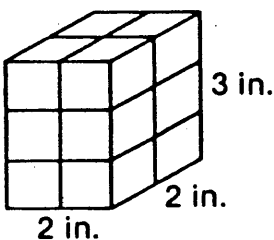
Give each volume. [Obj. 9-4, page 262]

28.



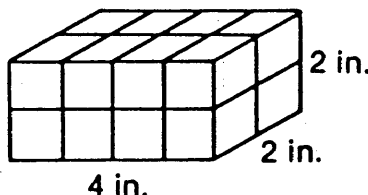
_____ cubic in.

29.



_____ cubic in.

30.



_____ cubic in.

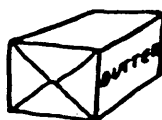
Choose the answer that seems right. [Obj. 9-5, pages 263-264]

31.



1 c or 1 gal

32.



1 oz or 1 lb

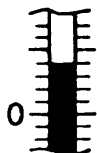
33.



4 oz or 4 lb

Give each temperature. [Obj. 9-6, page 265]

34.



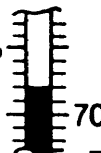
_____ °F

35.



_____ °F

36.



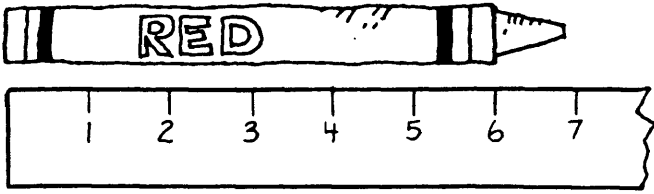
_____ °F

Appendix D
Basic Worksheets
from
Heath Mathematics

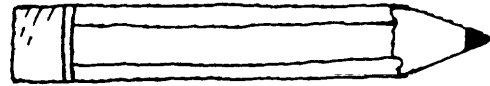
Name _____

Basic Worksheet for 242-243

Estimate by looking at the centimeter ruler.



about 7 centimeters



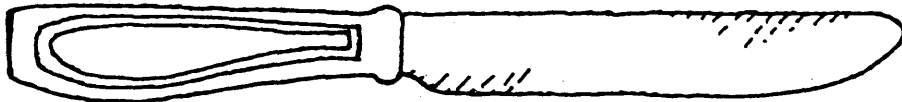
about _____ centimeters



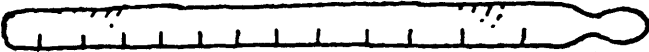
about _____ centimeters



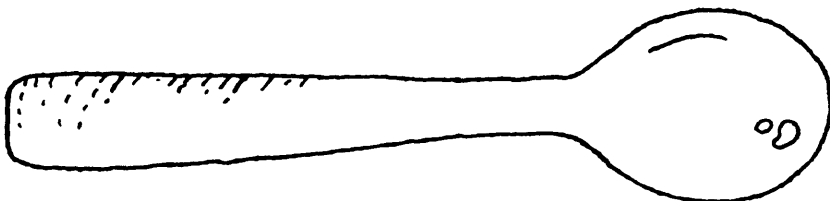
about _____ centimeters



about _____ centimeters



about _____ centimeters



about _____ centimeters



Name _____

Basic Worksheet for 244 – 245

Complete.

Remember that 1 meter (m) = 100 centimeters (cm).

Look at a meter stick if you need to.

$1 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 2 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 3 \text{ m} = \underline{\hspace{2cm}} \text{ cm}$

$4 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 5 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 6 \text{ m} = \underline{\hspace{2cm}} \text{ cm}$

$7 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 8 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 9 \text{ m} = \underline{\hspace{2cm}} \text{ cm}$

$10 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 11 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 12 \text{ m} = \underline{\hspace{2cm}} \text{ cm}$

$13 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 14 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 15 \text{ m} = \underline{\hspace{2cm}} \text{ cm}$

$23 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 54 \text{ m} = \underline{\hspace{2cm}} \text{ cm} \quad 20 \text{ m} = \underline{\hspace{2cm}} \text{ cm}$

$300 \text{ cm} = \underline{\hspace{2cm}} \text{ m} \quad 700 \text{ cm} = \underline{\hspace{2cm}} \text{ m} \quad 900 \text{ cm} = \underline{\hspace{2cm}} \text{ m}$

$100 \text{ cm} = \underline{\hspace{2cm}} \text{ m} \quad 200 \text{ cm} = \underline{\hspace{2cm}} \text{ m} \quad \overset{*}{2500 \text{ cm}} = \underline{\hspace{2cm}} \text{ m}$

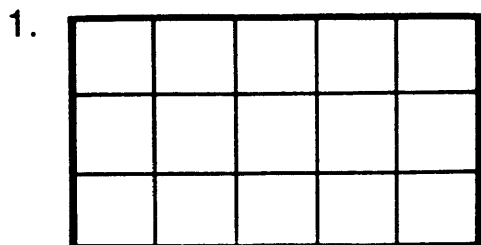
Name _____

Basic Worksheet for 246–247

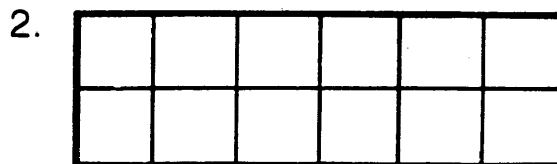
How many centimeters around is it?



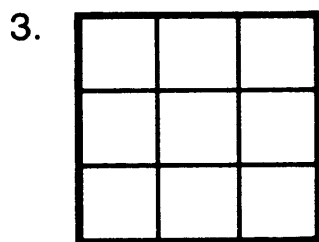
¹ centimeters ²



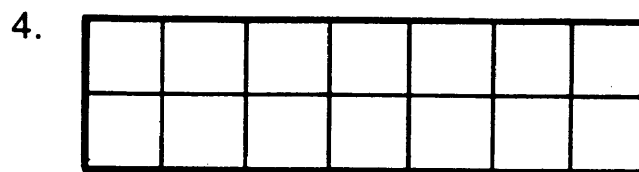
16 centimeters around



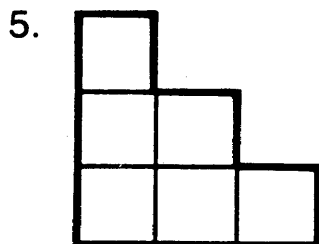
_____ centimeters around



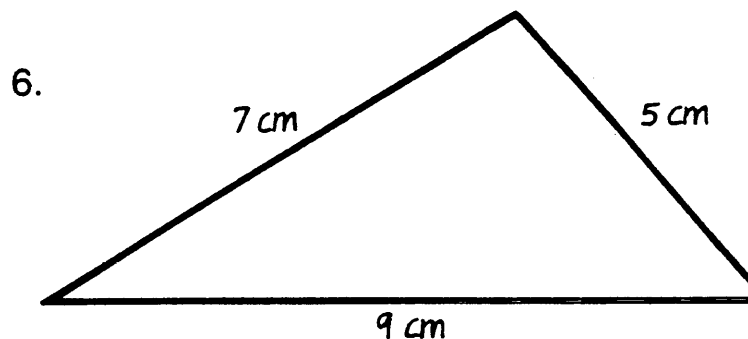
_____ centimeters around



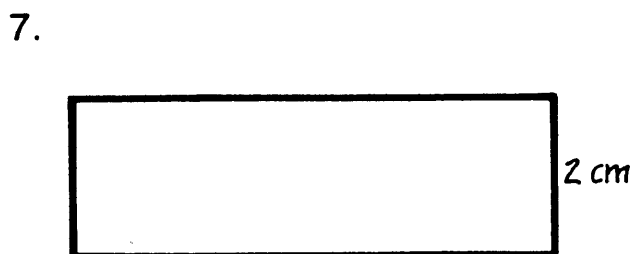
_____ centimeters around



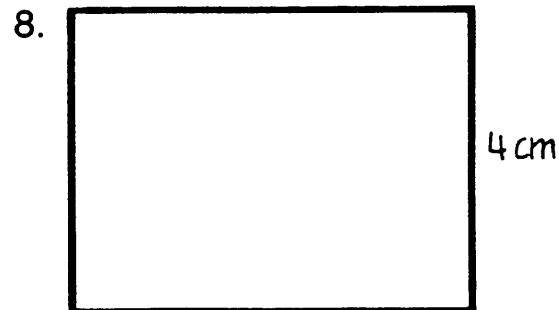
_____ centimeters around



_____ centimeters around



_____ centimeters around

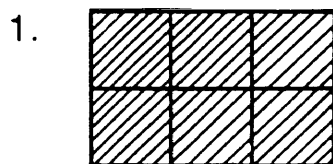
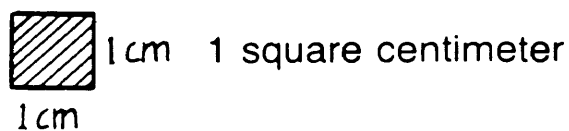


_____ centimeters around

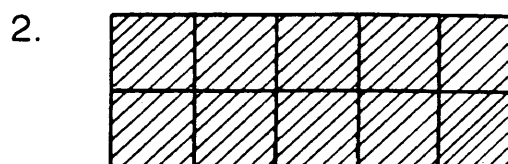
Name _____

Basic Worksheet for 248–249

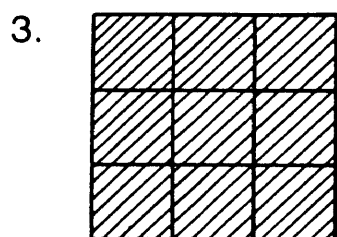
Give each area.



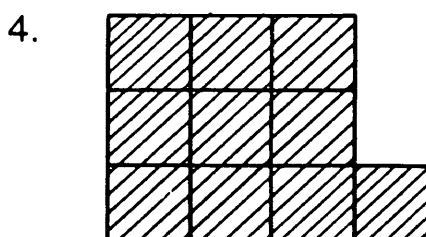
6 square centimeters



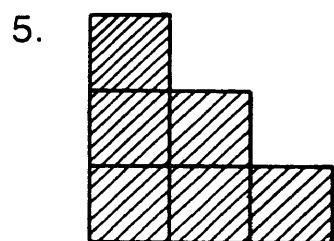
_____ square centimeters



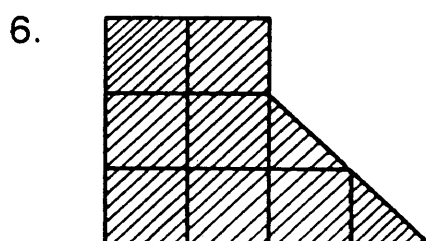
_____ square centimeters



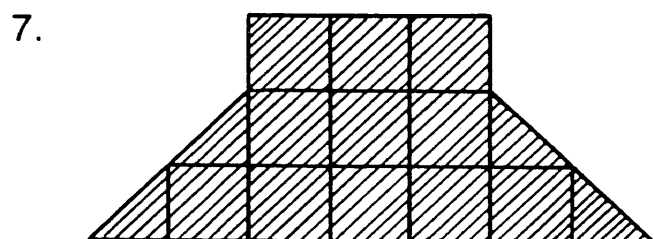
_____ square centimeters



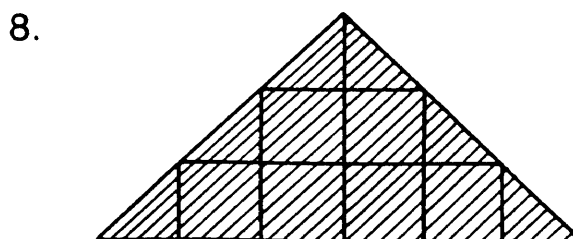
_____ square centimeters



_____ square centimeters



_____ square centimeters

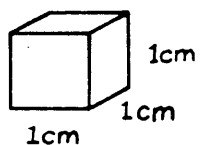


_____ square centimeters

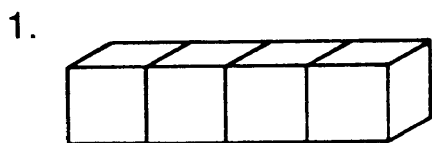
Name _____

Basic Worksheet for 250–251

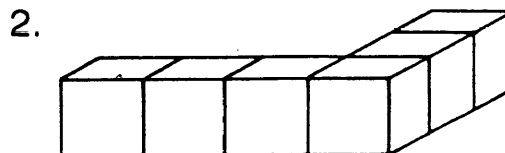
Give each volume.



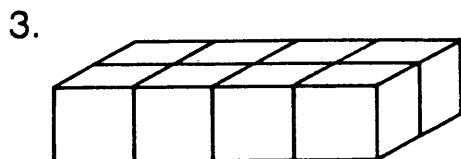
1 cubic centimeter



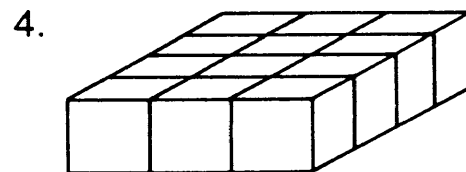
_____ cubic centimeters



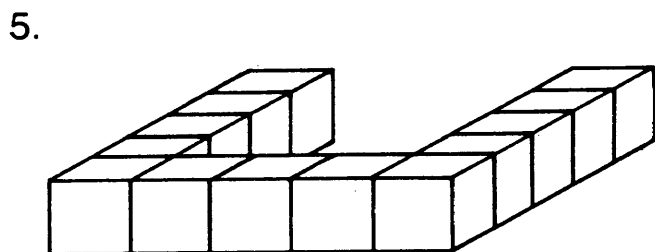
_____ cubic centimeters



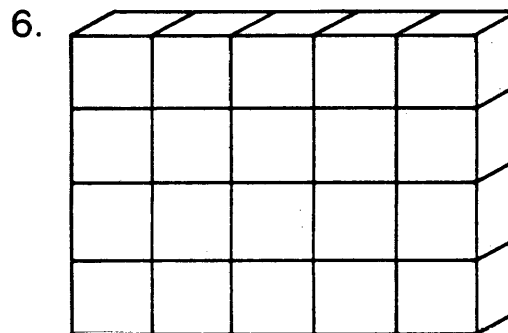
_____ cubic centimeters



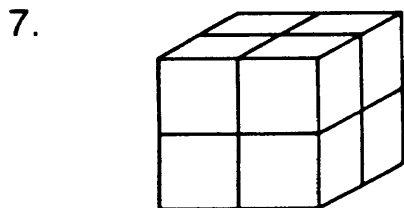
_____ cubic centimeters



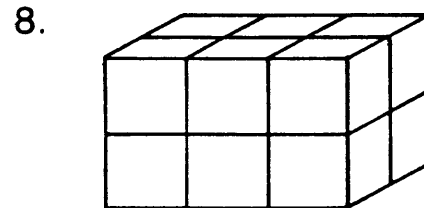
_____ cubic centimeters



_____ cubic centimeters



_____ cubic centimeters



_____ cubic centimeters

Name _____

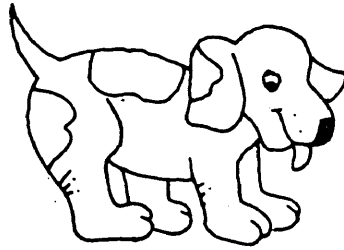
Basic Worksheet for 252–253

Choose the answer that seems right.

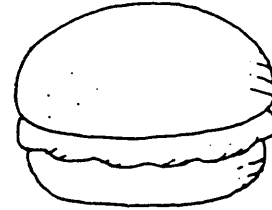
Remember: g is gram
kg is Kilogram



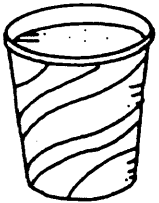
2 g 2 kg



17 g 17 kg



460 g 460 kg



520 g 520 kg



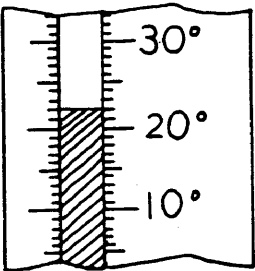
5 g 5 kg



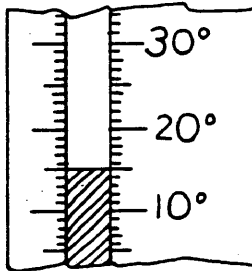
6 g 6 kg

Remember:
°C is degrees Celsius

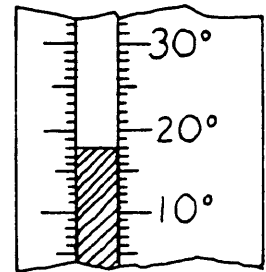
Give each temperature.



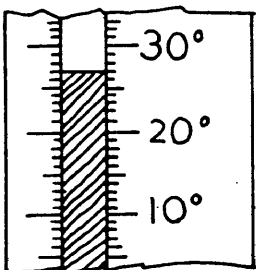
_____ °C



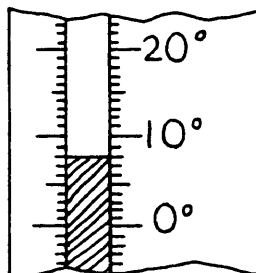
_____ °C



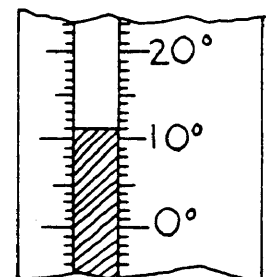
_____ °C



_____ °C



_____ °C

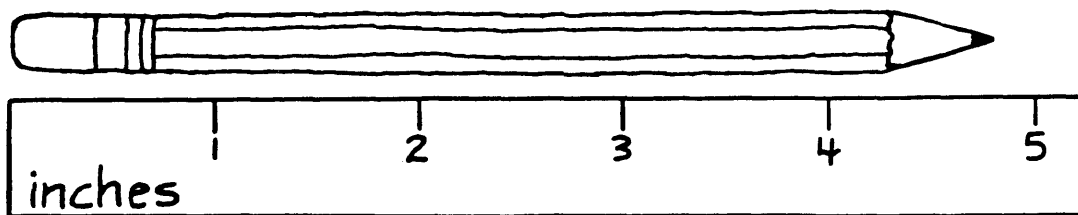
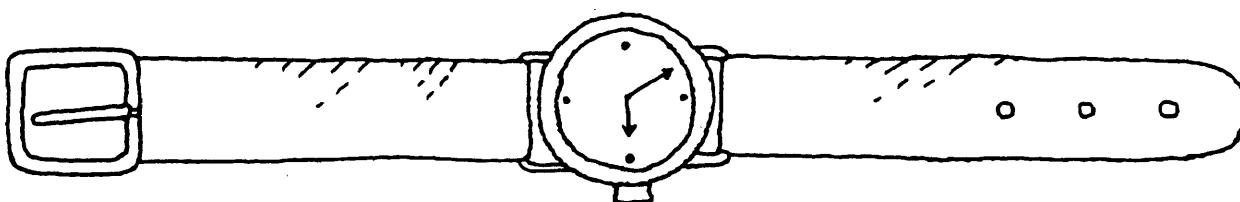


_____ °C

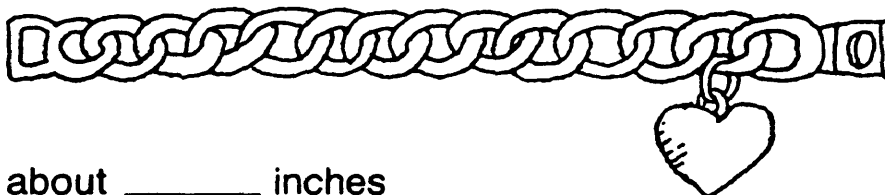
Name _____

Basic Worksheet for 254 – 255

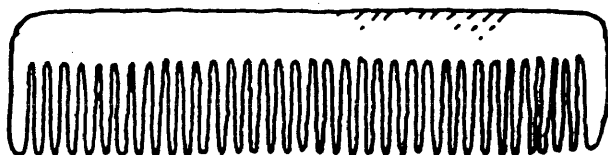
Estimate by looking at the inch ruler.

about 5 inches

about _____ inches



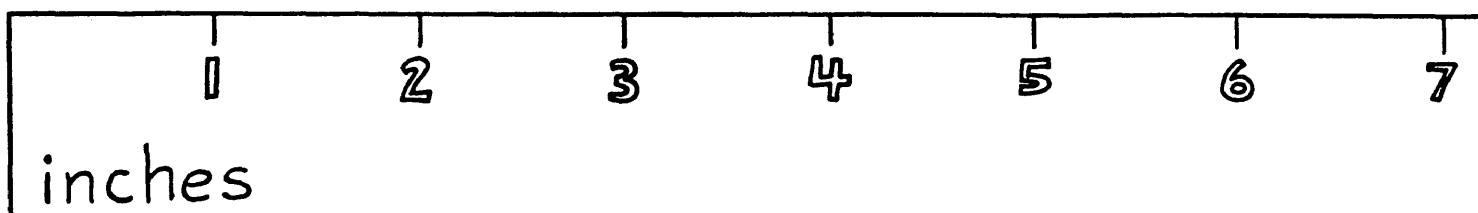
about _____ inches



about _____ inches



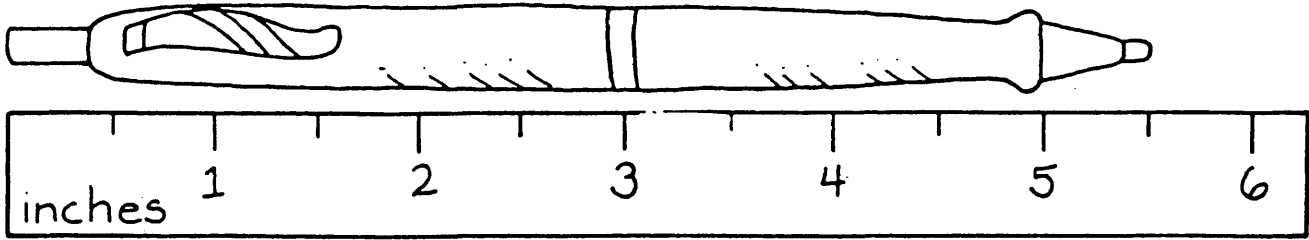
about _____ inches



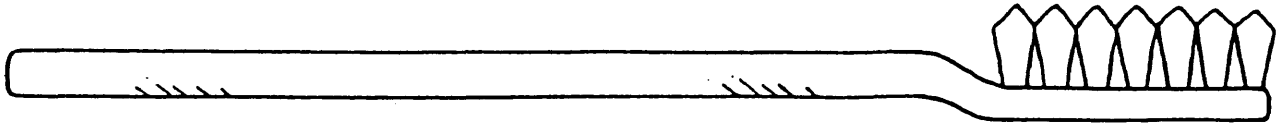
Name _____

Basic Worksheet for 256 - 257

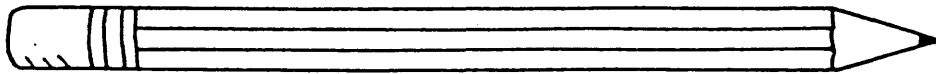
Estimate to the nearest half-inch by looking at the inch ruler.



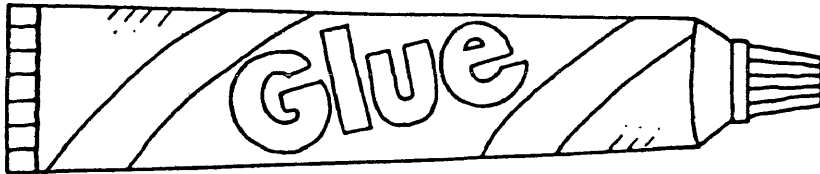
about _____ inches



about _____ inches



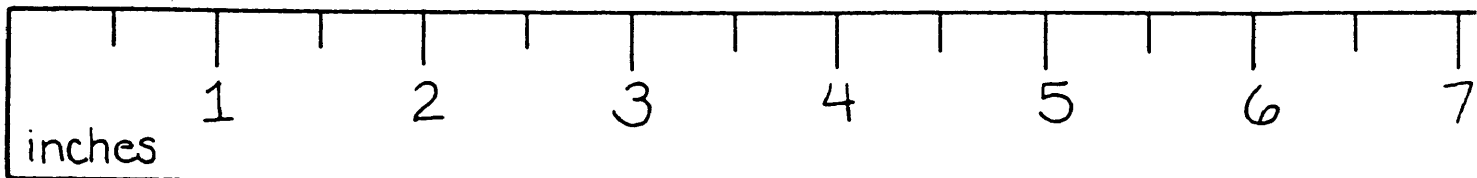
about _____ inches



about _____ inches



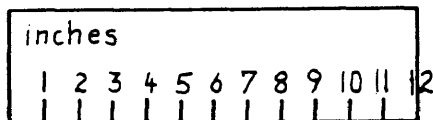
about _____ inches



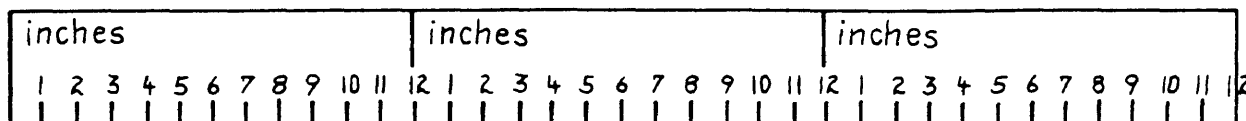
Name _____

Basic Worksheet for 258–259

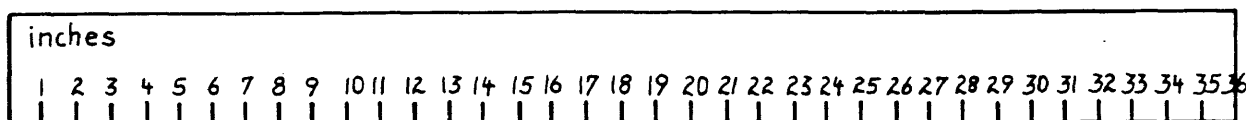
1 foot (ft) = 12 inches (in.)



1 yard (yd) = 3 feet (ft)



1 yard (yd) = 36 inches (in.)



Complete.

1 ft = 12 in. 3 ft = _____ yd 2 ft = _____ in.

24 in. = _____ ft 36 in. = _____ yd 12 in. = _____ ft

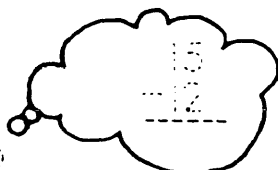
6 ft = _____ yd 6 yd = _____ ft 3 yd = _____ ft

15 in. = 1 ft and 3 in. 26 in. = _____ ft and _____ in.

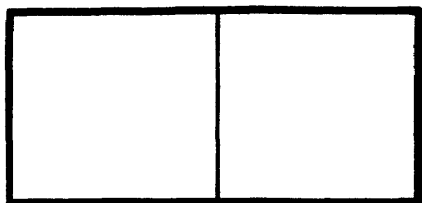
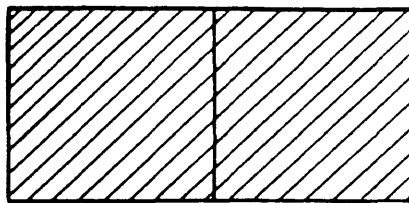
18 in. = _____ ft and _____ in. 30 in. = _____ ft and _____ in.

1 ft and 8 in. = _____ in. 1 ft and 11 in. = _____ in.

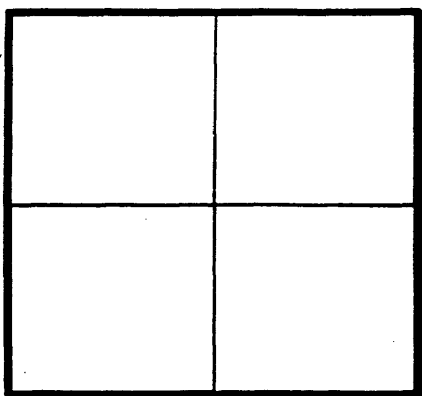
2 ft and 8 in. = _____ in. 2 ft and 11 in. = _____ in.



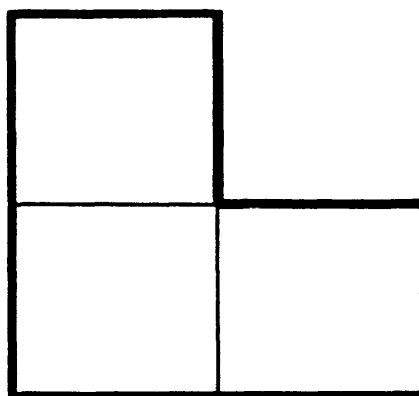
Name _____

Basic Worksheet for 260–261Perimeter is 6 inches.Area is 2 square inches.

Give the perimeter.

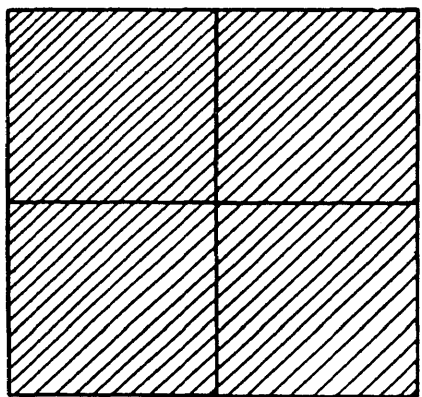


Perimeter is _____ inches.

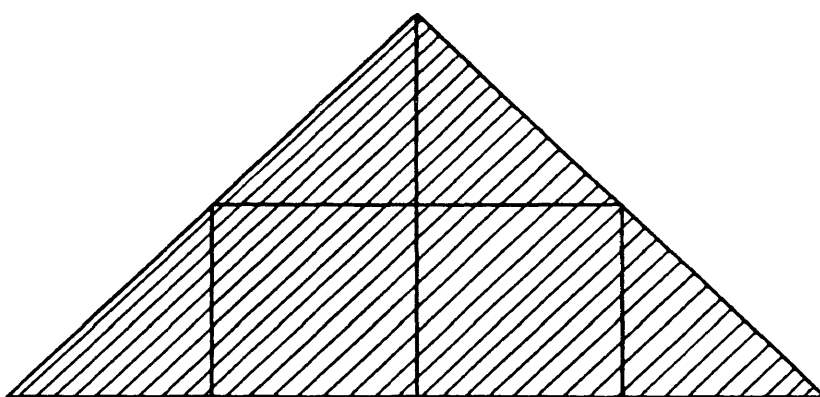


Perimeter is _____ inches.

Give the area.



Area is _____ square inches.

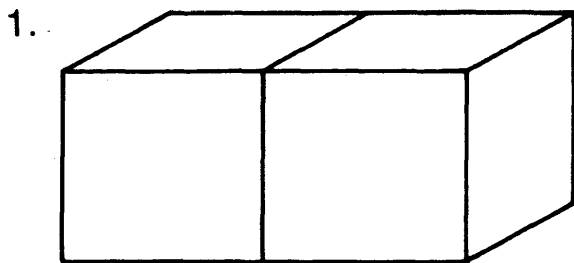
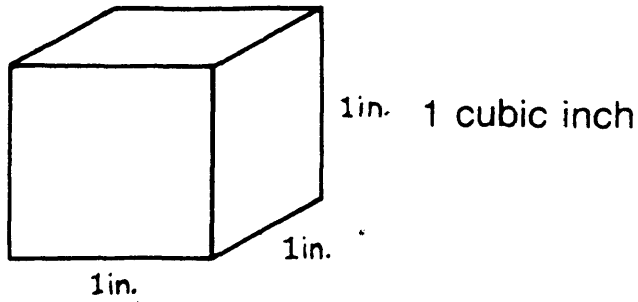


Area is _____ square inches.

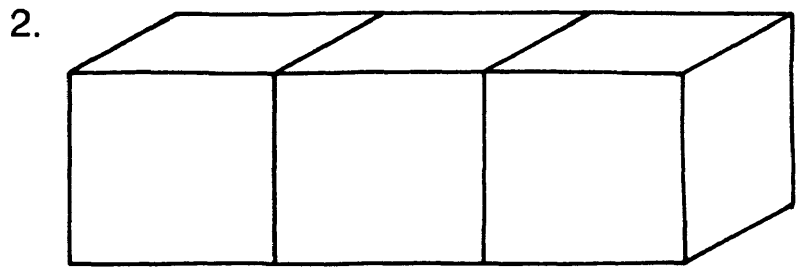
Name _____

Basic Worksheet for 262–263

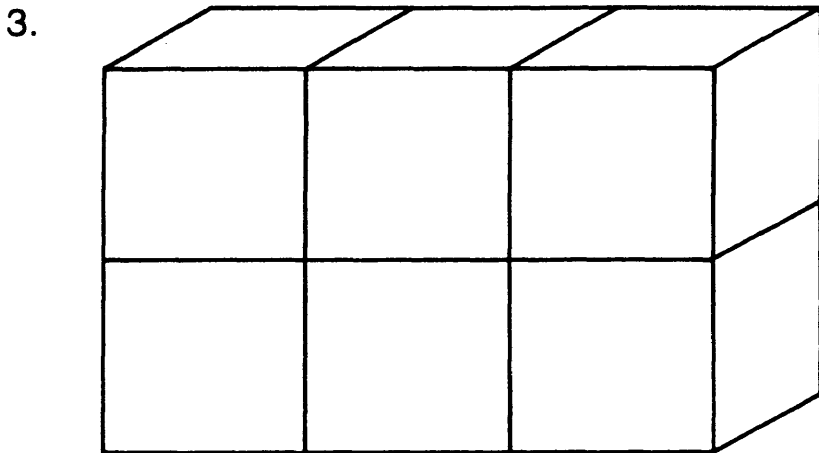
Give the volume.



2 cubic inches



_____ cubic inches



_____ cubic inches

2 cups (c) = 1 pint (pt)

2 pints (pt) = 1 quart (qt)

4 quarts (qt) = 1 gallon (gal)

Complete.

1 qt = 2 pt

1 pt = _____ c

1 gal = _____ qt

3 qt = _____ pt

5 pt = _____ c

6 gal = _____ qt

8 pt = _____ qt

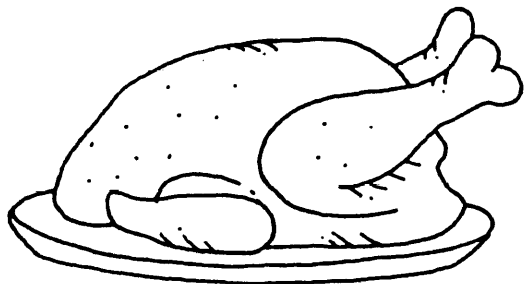
10 c = _____ pt

12 qt = _____ gal

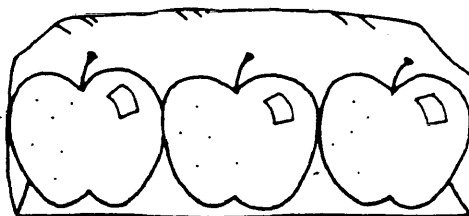
Name _____

Basic Worksheet for 264 – 265

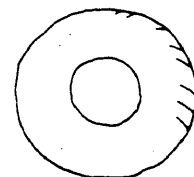
Mark the answer that seems right.



6 oz 6 lb

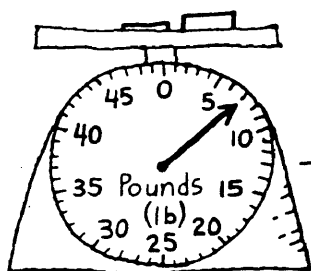


14 oz 14 lb

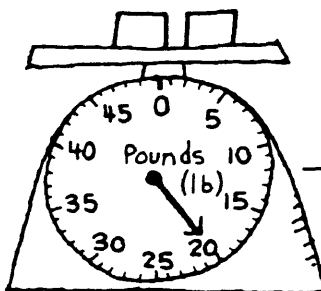


2 oz 2 lb

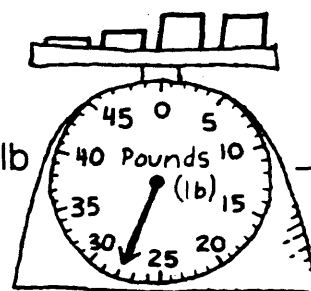
Give each weight.



_____ lb

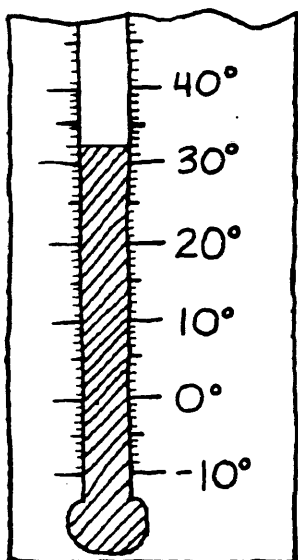


_____ lb

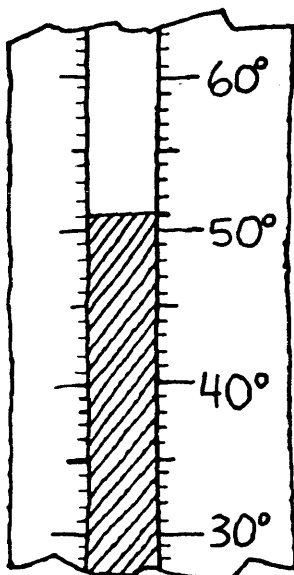


_____ lb

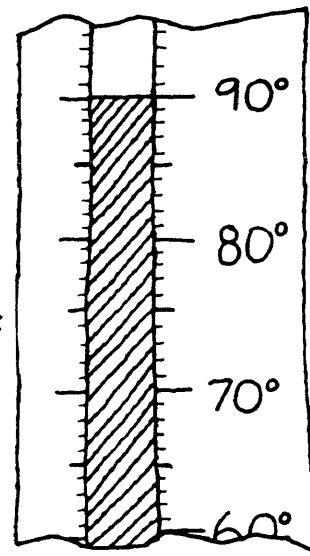
What is the temperature?



°F



°F



°F

Appendix E
Student Objectives and
Daily Group Lessons

Lesson 1

Student Objective: The student will measure with a centimeter ruler.

Experimental Group: The students were provided a box of pencils of various lengths, paper clips, scissors, and other objects to measure with centimeter rulers. They attempted to find the length in centimeters of each object.

Control Group: The students in this group measured various lengths of pencils on a printed page. They also measured other printed objects such as a thermometer and a spoon to find the length in centimeters of each object. Calculated answers were recorded for this assignment.

Both groups were provided a definition for the term "centimeter".

Lesson 2

Student Objective: The student will measure with a centimeter ruler, measure with a meterstick, and compare centimeters and meters.

Experimental Group: The students were provided both centimeter and meter rulers to measure the lengths of various objects such as the cafeteria doors, chairs, and tables. The children in this group worked to find the measurements with both centimeter and meter rulers.

Control Group: The students in this group worked from prepared booklets to determine the lengths of various objects depicted in the booklets using meter and centimeter rulers pictured on each page. Calculated results were recorded for this assignment.

Lesson 3

Student Objective: The student will find the perimeter of a figure in a standard unit of measurement.

Experimental Group: The students were provided square blocks, geoboards and patterned grids to determine various perimeters.

Control Group: The students in this group worked to determine the perimeter of each figure on the printed pages. Calculated figures were recorded for this assignment.

Both groups were provided a definition for the term "perimeter".

Lesson 4

Student Objective: The student will find the area of a region by counting the centimeter squares inside the region.

Experimental Group: The students were provided square blocks, geoboards and patterned grids to determine various areas.

Control Group: The students in this group worked to determine the area of each printed figure of reproduced graph paper. Calculated figures were recorded for this assignment.

Both groups were provided a definition for the term "area".

Lesson 5

Student Objective: The student will find the volume of a rectangular solid by counting the number of centimeter cubes necessary to fill the solid.

Experimental Group: The students were provided square blocks, geoboards and patterned grids to determine various volumes. Different levels were built on the existing grids to provide depth for the concept of volume.

Control Group: The students in this group worked to determine the volume of the printed block diagrams. Calculated figures were produced by counting the number of blocks in cubic centimeters.

Both groups were provided a definition for the term "volume".

Lesson 6

Student Objective: The student will choose reasonable estimates of weight using metric measures.

Experimental Group: The students were provided various objects to measure such as paper clips, erasers and pennies. A small scale was used to weigh the smaller pieces with various gram cubes being used as counterbalances. a larger scale weighed all heavier objects such as a hammer and a few chairs. The weights of the lighter articles were calculated in grams and weights of the heavier items in kilograms. Students discovered how many grams were contained in one kilogram.

Control Group: The students in this group worked to determine a reasonable weight in either grams or kilograms for various printed materials such as erasers, pennies, paper clips, books, pencils and football players. They discovered how many grams were contained in one kilogram. Students chose what they believed to be the most accurate estimate for each figure.

Both groups were provided definitions for the terms "gram" and "kilogram".

Lesson 7

Student Objective: The student will choose reasonable estimates of temperature using metric measures.

Experimental Group: The students were provided thermometers to measure temperature readings of ice, cold water, hot water, the outdoors and the inside of the cafeteria. The children learned how to read each of these individual temperatures.

Control Group: The students in this group worked to determine temperature readings of various printed thermometers showing a hot summer day at the beach, the inside of a house and a cold winter day. The children learned how to read each of these individual temperatures. Calculated figures were recorded for each thermometer reading.

Both groups were provided a definition for the term "degree Celsius".

Lesson 8

Student Objective: The student will measure lengths using an inch ruler.

Experimental Group: The students were provided various articles such as pencils, combs, crayons, straws, erasers and cardboard boxes. Rulers and yardsticks provided the children a way to measure these objects. Other objects such as books, chairs and tables were also used to provide calculated dimensions in inch measurements.

Control Group: The students in this group worked to determine reasonable measurements of certain printed objects such as pencils, watches, charm bracelets and combs. Calculated answers were produced by choosing the most accurate estimate of each figure to the nearest inch.

Both groups were provided a definition for the term "inch".

Lesson 9

Student Objective: The student will measure segments to the nearest half-inch.

Experimental Group: The students were provided various articles such as pencils, straws, paint brushes, pens, plastic containers and other material. Rulers and yardsticks provided the children a way to measure these objects. Other objects such as doors, chairs, tables and pieces of wood were also used to provide calculated dimensions in inch measurements.

Control Group: The students in this group worked to determine reasonable measurements of certain printed objects such as tooth brushes, pencils, glue bottles, pens, paper clips and other articles. Calculated answers were produced by choosing the most accurate estimate of each figure to the nearest half-inch.

Both groups were provided a definition for the term "half-inch".

Lesson 10

Student Objective: The student will measure lengths using inches, feet and yards and make conversions between inches, feet and yards.

Experimental Group: The students were provided rulers and yardsticks to make conversions from yards to feet and from feet to inches. Various measurements such as the width of the room, length of the hall, length of the lunchroom tables and other various lengths were recorded in yards, feet and inches.

Control Group: The students in this group worked to determine conversions of different printed measurements. A printed picture of a ruler and yardstick helped the children make conversions from yards to feet and from feet to inches. Calculated answers were produced by choosing the most accurate estimate of each printed figure in both yards and feet, and feet and inches.

Both groups were provided a definition for the terms "feet" and "yards".

Lesson 11

Student Objective: The student will determine the area of a figure by counting the inch squares that cover each figure and will find the perimeter of a figure in a conventional unit of measurement.

Experimental Group: The students were provided square blocks, geoboards and patterned grids to determine various perimeters and areas.

Control Group: The students in this group worked to determine both the area and perimeter of each printed figure of blocks. Calculated figures were recorded for this assignment.

Both groups were provided a review for the terms "area" and "perimeter".

Lesson 12

Student Objective: The student will determine the volume of a solid composed of one inch cubes by counting the cubes.

Experimental Group: The students were provided square blocks, geoboards and patterned grids to determine various volumes.

Control Group: The students in this group worked to determine the volume of each printed figure of blocks. Calculated figures were recorded for this assignment.

Both groups were provided a definition for the term "volume".

Lesson 13

Student Objective: The student will make conversions between cups, pints, quarts and gallons.

Experimental Group: The students were provided plastic containers, measuring cups, pints, quarts, gallons and colored water to use in making comparisons.

Control Group: The students in this group worked to determine the relationships between cups, pints, quarts and gallons from printed exercises. Calculated figures were recorded for this assignment.

Both groups were provided definitions for the terms "cup", "pint", "quart" and "gallon".

Lesson 14

Student Objective: The student will determine weight by using conventional measures.

Experimental Group: The students were provided books, tools, cups, erasers and other various objects to weigh on a scale showing pounds and ounces. Lighter articles were weighed in ounces and the heavier items in pounds. Students discovered how many ounces were contained in one pound.

Control Group: The students in this group worked to determine a reasonable weight in either ounces or pounds for various printed materials such as bicycles, apples, birds, hamburgers and books. Students discovered how many ounces were in a pound. Calculated answers were produced by choosing the most accurate estimate for each figure.

Both groups were provided definitions for the terms "ounce" and "pound".

Lesson 15

Student Objective: The student will determine temperature using conventional measures.

Experimental Group: The students were provided thermometers to measure temperature readings of ice, cold water, hot water, the outdoors and the inside of the cafeteria. The children learned how to read each of these individual temperatures.

Control Group: The students in this group worked to determine temperature readings of various printed thermometers showing a hot summer day, a cold winter day and so on. The children learned how to read each of these individual temperatures. Calculated figures were recorded for each thermometer reading.

Both groups were provided a definition for the term "degree Fahrenheit".

Lesson 16

Student Objective: The student will review previously taught concepts as demonstrated in this measurement unit.

Experimental Group: The students were provided various stations where they demonstrated the mastery of each concept taught in the first fifteen lessons. The required manipulative materials were present at each station.

Control Group: The students in this group were provided activities on two printed pages to demonstrate the mastery of each concept taught in the first fifteen lessons. All materials used were on each printed page. Calculated answers were recorded for this assignment.

Lesson 17

All children were administered a post test which covered the material presented in the fifteen lessons.

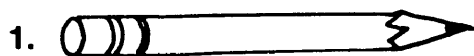
Appendix F
Heath Mathematics
Post Test

Chapter 9 Posttest

Name _____

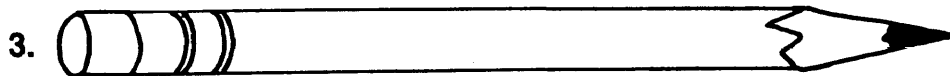
Part A Metric system

Measure with a centimeter ruler. [Obj. 9-1, pages 242-245]



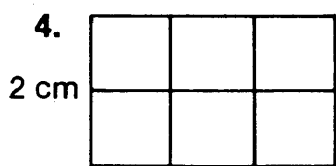
_____ cm

_____ cm

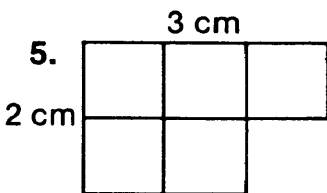


_____ cm

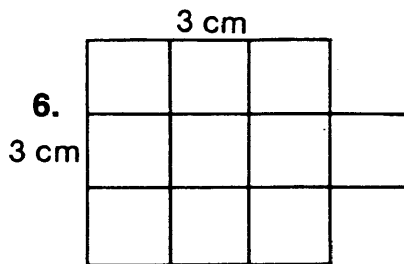
Give the perimeter. [Obj. 9-2, pages 246-247]



_____ cm



_____ cm



_____ cm

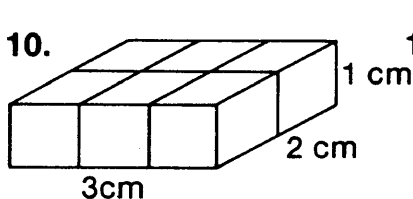
Give the area of each figure above. [Obj. 9-3, pages 248-249]

7. _____ square cm

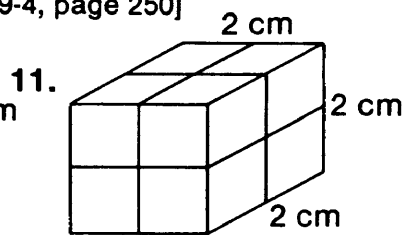
8. _____ square cm

9. _____ square cm

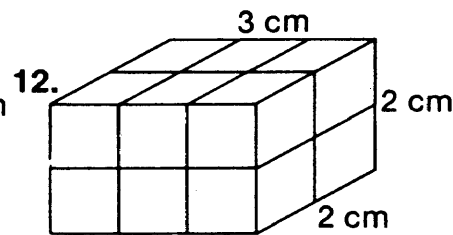
Give each volume. [Obj. 9-4, page 250]



_____ cubic cm



_____ cubic cm



_____ cubic cm

Choose the answer that seems right. [Obj. 9-5, pages 251-252]



1 liter or 10 liters

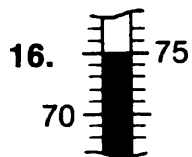


1 g or 1 kg

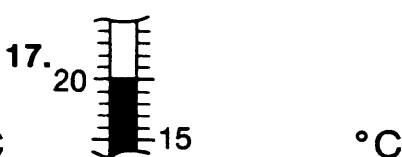


2 g or 2 kg

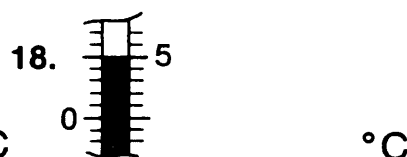
Give each temperature. [Obj. 9-6, page 253]



_____ °C



_____ °C



_____ °C

Answers

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

11. _____

12. _____

13. _____

14. _____

15. _____

16. _____

17. _____

18. _____

Chapter 9 Posttest

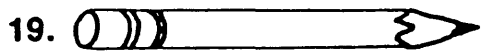
Name _____

Answers

(continued)

Part B Customary system

Measure with a half-inch ruler. [Obj. 9-7, pages 254-259]



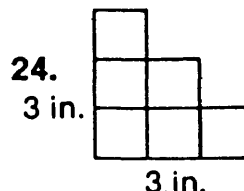
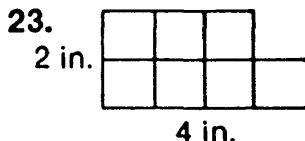
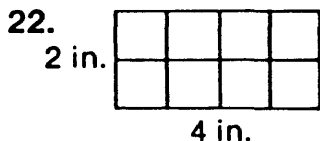
_____ in.

_____ in.



_____ in.

Give the perimeter. [Obj. 9-2, pages 260-261]



_____ in.

_____ in.

_____ in.

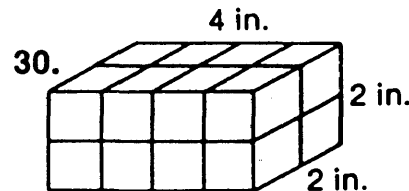
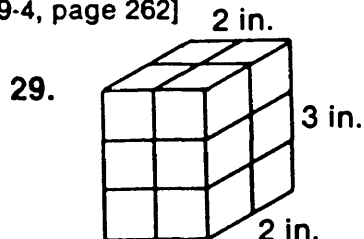
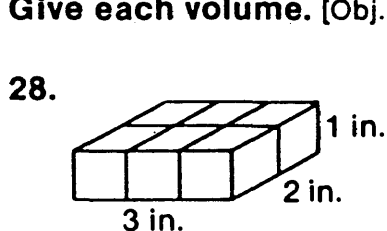
Give the area of each figure above. [Obj. 9-3, pages 260-261]

25. _____ square in.

26. _____ square in.

27. _____ square in.

Give each volume. [Obj. 9-4, page 262]



_____ cubic in.

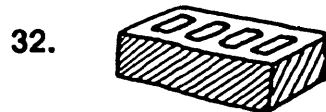
_____ cubic in.

_____ cubic in.

Choose the answer that seems right. [Obj. 9-5, pages 263-264]



2 c or 2 gal

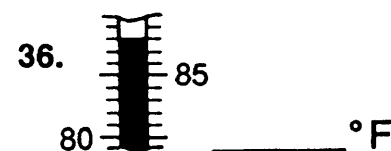
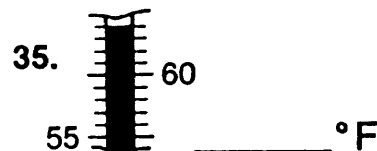
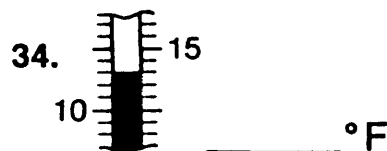


2 oz or 2 lb



3 oz or 3 lb

Give each temperature. [Obj. 9-6, page 265]



- 19. _____
- 20. _____
- 21. _____
- 22. _____
- 23. _____
- 24. _____
- 25. _____
- 26. _____
- 27. _____
- 28. _____
- 29. _____
- 30. _____
- 31. _____
- 32. _____
- 33. _____
- 34. _____
- 35. _____
- 36. _____

Appendix G

CTBS / PRETEST SCORES

Math Subset CTBS Test Scores

Experimental Group
(Student %)

1.	92
2.	90
3.	88
4.	86
5.	84
6.	82
7.	82
8.	82
9.	78
10.	70
11.	62
12.	58

Control Group
(Student %)

1.	92
2.	90
3.	88
4.	86
5.	84
6.	82
7.	82
8.	82
9.	76
10.	68
11.	64
12.	56

Math Subset CTBS Test Scores

Experimental Group
(Student %)

1.	95
2.	88
3.	85
4.	85
5.	80
6.	78
7.	75
8.	72
9.	60
10.	51
11.	45
12.	37

Control Group
(Student %)

1.	95
2.	90
3.	83
4.	83
5.	78
6.	78
7.	74
8.	74
9.	58
10.	53
11.	49
12.	35

Appendix H
Permission Information

TO: Richard B. Atwood
FROM: Dorothy McLeod
D.C. Heath Company
DATE: April 16, 1991
RE: Permission to use copies of D.C. Heath Mathematics worksheets in
masters thesis

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