

Instructor's Manual

Eighth Edition

Engineering Graphics



Giesecke Mitchell Spencer Hill Loving Dygdon Novak

Gerald L. Bacza

Instructor's Manual

Eighth Edition

Engineering Graphics

Giesecke Mitchell Spencer Hill Loving Dygdon Novak

Gerald L. Bacza



Upper Saddle River, New Jersey 07458

Executive Editor: *Eric Svendsen*
Associate Editor: *Dee Bernhard*
Executive Managing Editor: *Vince O'Brien*
Managing Editor: *David A. George*
Production Editor: *Barbara A. Till*
Supplement Cover Manager: *Daniel Sandin*
Manufacturing Buyer: *Ilene Kahn*



© 2004 by Pearson Education, Inc.
Pearson Prentice Hall
Pearson Education, Inc.
Upper Saddle River, NJ 07458

All rights reserved. No part of this book may be reproduced in any form or by any means, without permission in writing from the publisher.

The author and publisher of this book have used their best efforts in preparing this book. These efforts include the development, research, and testing of the theories and programs to determine their effectiveness. The author and publisher make no warranty of any kind, expressed or implied, with regard to these programs or the documentation contained in this book. The author and publisher shall not be liable in any event for incidental or consequential damages in connection with, or arising out of, the furnishing, performance, or use of these programs.

Pearson Prentice Hall® is a trademark of Pearson Education, Inc.

Printed in the United States of America

6 7 8 9 10 11 12 V036 12 11 10

ISBN 0-13-141524-7

Pearson Education Ltd., *London*
Pearson Education Australia Pty. Ltd., *Sydney*
Pearson Education Singapore, Pte. Ltd.
Pearson Education North Asia Ltd., *Hong Kong*
Pearson Education Canada, Inc., *Toronto*
Pearson Educación de México, S.A. de C.V.
Pearson Education—Japan, *Tokyo*
Pearson Education Malaysia, Pte. Ltd.
Pearson Education, Inc., *Upper Saddle River, New Jersey*

Contents

1	The Graphic Language and Design	1
2	Introduction to CAD	5
3	Instrumental Drawing, Freehand Sketching and Lettering Techniques	7
4	Geometric Construction	29
5	Technical Sketching and Shape Description	35
6	Multiview Projection	39
7	Sectional Views	44
8	Auxiliary Views	48
9	Revolutions	50
10	Manufacturing Design and Processes	51
11	Dimensioning	53
12	Tolerancing	60
13	Thread, Fasteners, and Springs	66
14	Design and Working Drawings	68
15	Drawing Reproduction, Control and the Internet	70
16	Axonometric Projection	71
17	Oblique Projection	74
18	Perspective	75
19	Points, Lines and Planes	76
20	Parallelism and Perpendicularity	78
21	Intersections	79
22	Developments	81
23	Line and Plane Tangencies	83

24	Cartography, Geology and Spherical Geometry	84
25	Graphical Vector Analysis	85
	Sample Course Syllabus	86
	Student Personal Competency Record	89
	Question database	91

Suggested Answers for Review Questions

1. What is the role of the engineer on the design team?

Engineers are experts using technical drawings and specifications to solve engineering problems. They provide the expertise to design products, systems, devices, and structures.

2. What is the difference between mechanical drawing and sketching?

Mechanical drawing is the term applied to a drawing made with drawing instruments. Sketching is the freehand expression of the graphic language, to convey technical ideas quickly and effectively without the use of special equipment.

3. Describe the main difference between parallel projection and perspective projection.

If the observer's eye is imagined as infinitely distant from the object and the plane of projection, then the projectors would be parallel, hence the term "parallel projection". In the case where the observer's eye is at a defined distance to the object and the projectors form a cone of projectors, the resulting projection is known as perspective projection.

4. When is sketching an appropriate form of graphic communication?

Sketching provides technical persons a quick way to communicate ideas effectively, without the use of special drafting equipment.

5. Why are standards so important for members of the engineering design team?

It is intended to provide engineers, builders, industry, and science with a method of uniform graphic communication. Drafting standards are designated ANSI Y14 standards.

6. What is the most important new tool used by drafters?

To think, visualize and design in three dimensions.

7. What is the plane of projection?

This is an imagined transparent surface located between the object and the viewer. (In third angle projection)

8. What are projectors and how are they drawn?

Projectors are imaginary lines from key points on an object which are assumed to intersect the projection plane. Parallel projectors intersect the projection plane at right angles, whereas perspective projectors intersect the projection planes at any angle.

9. What is the design process?

An organized and orderly approach to solving problems involving engineering design.

10. What are the five phases of the design process?
- a. **problem identification**
 - b. **concepts and ideas**
 - c. **compromise solutions**
 - d. **models and/or prototypes**
 - e. **production and/or working drawings**

The Graphic Language and Design

Worksheet

Name: _____

1. Name the two general types of graphic representation:
 - a. _____
 - b. _____
2. Gaspard Monge is considered to be the inventor of _____
_____.
3. Explain the difference between third-angle projection and first-angle projection.
4. The abbreviation AMSE stands for:
_____.
5. The abbreviation ANSI stands for:
_____.
6. The term used to describe three dimensional geometry forming the background for the practical applications of the graphic language and used to graphically solve problems is:
_____.
7. A Communication skill or tool that is extremely valuable to Engineers, Scientists, and Technicians is _____.
8. List the four imaginary things behind every drawing of an object.

Identify which of the following projections is perspective or central projection and which are parallel projection.

9. Third-angle projection _____
10. Axonometric projection _____
11. Three-point projection _____
12. Orthographic projection _____

Answers to Worksheet

1. a. artistic
 b. technical
2. Descriptive Geometry
3. First angle projection is where the top view was placed under the front view and the left side view was placed on the right side.
 Third angle projection, currently used in the US is where the top view is placed above the front view and the right side view is placed on the right side.
4. American Society of Mechanical Engineers
5. American National Standards Institute
6. Descriptive Geometry
7. Freehand Sketching
8. The observer's eye (station point), the object, the plane of projection, and the projectors
9. parallel projection
10. parallel projection
11. perspective projection
12. parallel projection

Suggested Answers for Review Questions

1. What are the basic components of a computer-aided drawing (CAD) system?

The pieces of physical equipment are called hardware and includes output devices (monitor and printer), input devices, (keyboard and mouse), the processing unit (CPU), and data storage devices (floppy disk, hard drive, CD-ROMs). The program and instructions which enable the system to operate are classified as operating systems (Windows, UNIX). Programs which perform specific tasks are called application programs (AutoCAD, Microstation).

2. Discuss the relationship between CAD and CAM in modern design and manufacturing facilities.

CAD stands for Computer-aided Drafting, CAM stands for Computer-aided Manufacturing or Computer aided Machining. Frequently, these systems are integrated and are called CAD-CAM systems. This type of system permits designing and checking the part in the CAD system, then sending the data to the manufacturing department for construction of the designed part.

3. List the similarities and differences between a mouse and a digitizing pad with puck.

The mouse typically has 2 or 3 buttons. It is very popular because it is inexpensive, requires a small working area, and easy to use. Digitizing tables are much larger, usually much more expensive, and can be used to convert existing paper drawings into CAD format. A puck is used on a digitizing tablet or table. A mouse is not used on a digitizer.

4. What are the advantages of CAD over traditional drawing methods?

Drawings can be created and revised much faster. Transmission of drawings and models electronically is faster. Analyzing and engineering problem solving is greatly increased.

5. What is faster, a computer with a 100 Mhz microprocessor and a 500 MB hard disk, or a 500 Mhz computer with a 100 MB hard disk? Which will store more information?

The faster working computer is the one with a 500Mhz operating speed. The computer with 500MB hard disk is the one with more storage.

6. What is the difference between RAM storage and hard disk storage? What computer parts are typically found on the motherboard?

RAM (random access memory) is temporary memory that stores software and user files while running. This information is lost when the computer is turned off. RAM generally speeds up the operation of the computer. The Hard Disk is where information is stored for later retrieval. This storage device stores documentation and drawings created by the operator. Expansion slots, a fan, battery and cable connections are all found on the motherboard. (Refer to Figure 2.13)

7. What is the difference between plotting and printing?

Typically, plotters are bigger than printers. Plotters use pens, pencils or spray ink on the media. Plotters can also create an image electrostatically. Printers use a

rasterization process to convert images to a series of dots. Ink jets and laser printers work on this same principle.

8. What are the hardware and software specifications of your school's CAD system?

The hardware list might include – A 1 GB processor, 40 GB hard disk, 3 1/2" floppy, 512 MB RAM, & HP 500 ink jet. The software list might include – Windows XP, AutoCAD 2004 and Microsoft Office.

9. What are questions you should ask about any CAD system you consider buying?

1. What are the brand names of the equipment being used?
2. What are the warranty periods and what is included?
3. What types of CAD software are provided and what is the capability of the software?
4. What kind and type of training is available?
5. What about software updates? Who provides them?
6. Check the vendor reputation and do they have a 1-800 number?
7. Who currently uses the system?
8. How much memory is needed?
9. How many expansion slots are available?

Suggested Answers for Review Questions

1. What tools are used to draw straight lines?

T-square (Parallel straight edge or drafting machine) and triangles

2. What tools are used to draw arcs and circles?

Compasses and circle templates

3. Draw the alphabet of lines and label each line.

The instructor should evaluate the alphabet of lines for neatness, accuracy and detail drafting techniques. (Refer to Figure 3.9)

4. Describe the proper technique for erasing a line using an erasing shield.

Place the erasing shield so that a hole appears over the line you intend to erase. Include in the hole only that part of the line you wish to erase. Erase vigorously over the hole with the line in it.

5. Why is the pencil pulled and never pushed when drawing lines?

Tends to minimize lead breakage

6. Which architect's scale represents a size ratio of 1:24? Which metric scale represents a half size? Which engineering scale would be used for full size?

Architect's scale - $\frac{1}{4}$ " = 1'-0"

Metric scale - 1:2

Engineering Scale - the 10

7. Which scale type is the only one to use fractions of an inch?

An Architect's scale

8. Is the bevel of a compass lead sharpened on the inside or the outside surface?

Outside

9. What are the minimum number of points that you should connect when using an irregular curve?

three

10. What are the advantages of polyester film as a drawing media?

Available in rolls and sheets; has very good transparency and printing qualities; is excellent for use with ink; erasures are clean and the material has a high dimensional stability. It resists cracking, bending, and tearing.

11. What are the four standard types of projections?

Axonometric (Isometric), Oblique, Perspective, and Orthographic

12. What are the advantages using grid paper for sketching?

Grid paper is helpful for keeping lines straight and maintaining correct spacing. Grid paper eliminates the need for a scale.

13. What is the correct technique for sketching a circle or an arc?

Any one of several methods might be used.

The first method is to lightly sketch a square and then sketch in the arcs to complete the circle.

A second method may be used by marking off the radius in different directions and then sketching in the arcs to complete the circle. The radius may be laid off using a strip of paper to mark the distance, holding the pencil and using your little finger at the center, or using the two pencil method with one pencil being held at the center of the circle.

In most cases, you may sketch small arc segments to complete the circle or rotate the paper. Arcs are usually more easily sketched from the concave side of the curve.

14. Sketch the alphabet of lines. Which lines are thick? Which are thin? Which are very light and should not reproduce when copied?

The instructor should evaluate the alphabet of lines. These should be freehand sketched lines. (Refer to Figure 3.9)

Lines that are drawn thick include Visible lines and Cutting plane lines.

Lines drawn thin are Hidden lines, Dimension lines, Extension lines, Centerlines, and Phantom lines.

Construction lines and Guide lines are drawn very light so they are not reproduced when copied.

15. What is the advantage of sketching an object first before drawing it using CAD?

Sketching provides a quick and easy means of getting ideas on paper, to be later refined using CAD.

16. What is the difference between proportion and scale?

Scale usually controls the size of the object on your paper. In sketching this is not critical. Proportion insures the appearance of your parts of the object appears in relative size to the overall object. This is the most important aspect of sketching. Proportion is the relationship of one dimension to another.

17. What font provides the shape of standard engineering lettering?

Gothic style

18. Describe the characteristics of good freehand lettering.

Lettering should be legible, be easy to create, and use styles acceptable for traditional drawing and CAD drawing.

19. Why must guideline always be used for lettering?

To maintain uniform lettering height

20. How are sketches used in the design process?

Provide a means to organize your thoughts and record ideas, quickly, easily, with a low-cost method to explore solutions to problems.

Name: _____

1. There are four primary objectives in Drafting. Name them:

A. _____ B. _____

C. _____ D. _____

2. Which of the following is used to draw large circles?

- A. Drop-bow compass
- B. Beam compass
- C. Bow compass
- D. Dividers

3. The preferred method for securing paper to the drawing table is with:

_____.

4. (True or False) Ordinary writing pencils are frequently used for drafting.

5. According to your text, there are _____ different grades of lead. The lead you choose must be _____

enough to produce a jet black line, yet _____ enough not to smudge too easily.

6. When using a sandpaper pad, it is desirable to keep it in an _____ to prevent the particles of graphite from getting your paper and equipment dirty.

7. According to the Line alphabet, three lines are drawn thick, name them.

_____, _____, _____

8. A solid thin line is a _____ line.

9. A thin line with a long dash, then two short dashes is a _____ line.

10. Two lines are drawn very lightly, so they will not reproduce and are not erased. Name them.

11. Most inclined lines are drawn at a standard angle using the _____ degree triangle or the _____ degree triangle.

_____ degree triangle.

12. By combining the two triangles and straight edge, you are able to draw angles at _____, _____,

_____, _____, _____, and _____.

INSTRUCTOR'S NOTE: It is important to develop good drawing habits early in your drafting experience. When drawing vertical lines with the triangles, the right-handed draftsman will draw on the left side of the triangle, from bottom to top, moving your triangle across the 'T' Square from left to right. (These techniques are specified in your text.) Ask your instructor to explain if you do not understand.

13. What is a protractor used for?

14. Scales are used for measurement ONLY and are NEVER used to draw lines. Which scale is used for Civil Engineering work ?

15. The text identifies five different types of scales, name them:

A. _____ B. _____ C. _____

D. _____ E. _____

16. The engineers' scale is graduated in units of one inch divided into _____, _____, _____, _____, _____, and _____ parts to the inch.

17. The Architects' scale has _____ scales.

18. Scales are specified on drawings as ratios. How would you represent the scale of a drawing that was made with one inch of drawing size equal to ten feet of actual size?

19. Identify the four steps to use a compass.

20. When using the compass to draw circles, never use the _____ of the needle point.

21. The compass is used for drawing circles while dividers are used for _____.

22. Compasses are used to draw circular curves and arcs, what is used to draw non-circular arcs?

23. A drafting machine is a device that (according to your text) replaces

_____, _____, _____, and _____.

24. Uniformity of height, proportion, inclination, spacing is essential in lettering practice.
What aid is used to insure uniform height of letters ? _____
25. Which of the following is the pencil drafting media of choice?
- | | | | |
|----|------------|----|---------------|
| A. | mylar | D. | tracing cloth |
| B. | onion skin | E. | blueline |
| C. | vellum | | |
26. (True or False) Guide lines are absolutely essential and must be used all the time.
27. The minimum height for freehand lettering of dimensions on 'C' size drawings is _____.
28. The numbers on the Ames Lettering guide indicate heights of letters in _____.
29. You are using a HB .5mm pencil and decide it is too dark. Which of the following will provide lighter lines of the same thickness.
- | | | | |
|----|---------|----|---------|
| A. | HB .7mm | C. | 3H .5mm |
| B. | 3H .9mm | D. | HB .3mm |
30. Uniformity in spacing of letters is a matter of equalizing space by _____.

Answers...

1. a. accuracy
b. speed
c. legibility
d. neatness
2. b.
3. drafting tape
4. False
5. 18 grades – soft - hard
6. envelope
7. Visible lines, Cutting-plane lines, & Short-break lines
8. Section line
9. Dimension line
10. construction lines and guide lines
11. 45° and 30-60°
12. 15°, 30°, 45°, 60°, 75° & 90°
13. to measure angles
14. Engineering Scale
15. a. architectural
b. engineering
c. metric
d. decimal
e. mechanical engineer's
16. 10, 20, 30, 40, 50 & 60
17. 11
18. 1"=10'
19. a. set off the required radius on one of the centerlines
b. place the needle point at the exact intersection of the centerlines
c. adjust the compass to the required radius
d. lean the compass forward and draw the circle clockwise while rotating the handle between the thumb and forefinger.
20. plain end
21. measuring distances
22. irregular curve
23. scales, triangles, t-square & protractor
24. Ames lettering guide
25. c
26. T
27. 1/8"
28. 32nds of an inch
29. c
30. eye

Scale overhead templates

The next pages are templates for making overheads for classroom review. The first template is intended to be an aid when explaining how to use an Engineering Scale. The last five templates have questions printed on them. Answers and explanations for each are provided below.

The **_ Scale** is an architectural scale. Note that the sub-divided unit is divided into 12 units. Therefore, it signifies 12 inches. Each **_** inch unit signifies 1 foot. It measures approx 14'-5".

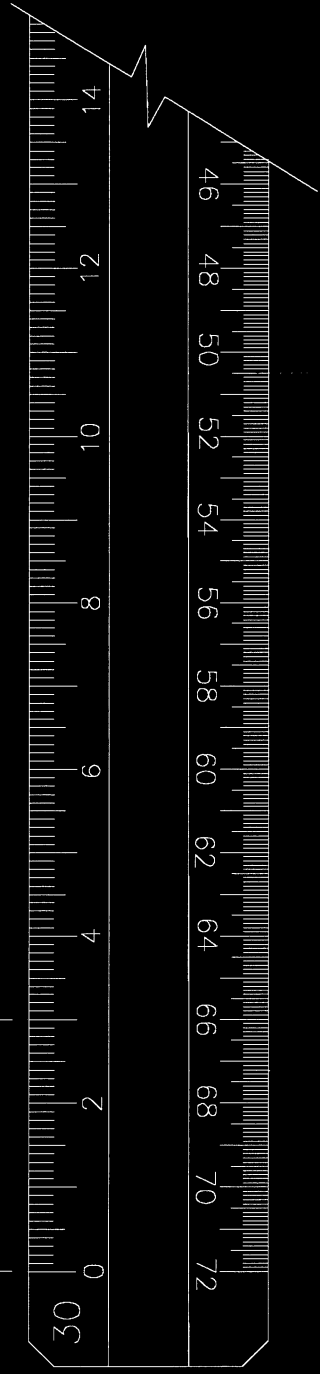
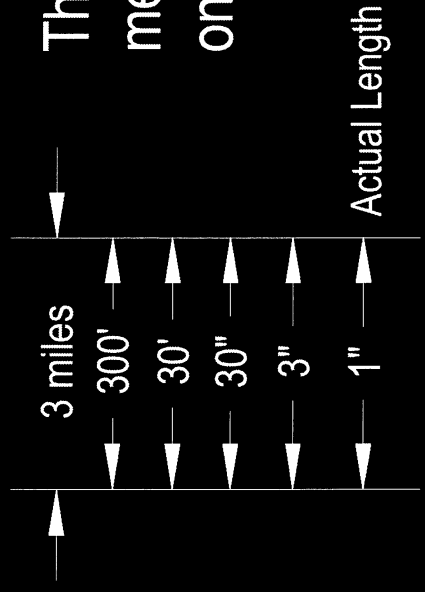
The **30 Scale** is a civil engineer scale. Each one inch segment is divided into 30 increments. This scale may represent 1"=3 units or 1"=30 units or 1"=300 units; etc. Therefore the measurement indicated may be 11.9 units or 119 units or 1,190 units.

The **1:2 Scale** is a metric scale. This scale will measure units at half size. The measurement indicates 188mm or 18.8cm or 1.88dm or 0.188m.

The **1 Scale** is an architectural scale. The sub-divided unit is divided into 48 units, a factor of 12. Therefore, the sub-divided unit represent inches and fractional parts of inches ($1/4$ " in this case). Each 1" signifies 1'. The measurement is 3'-5" (approx).

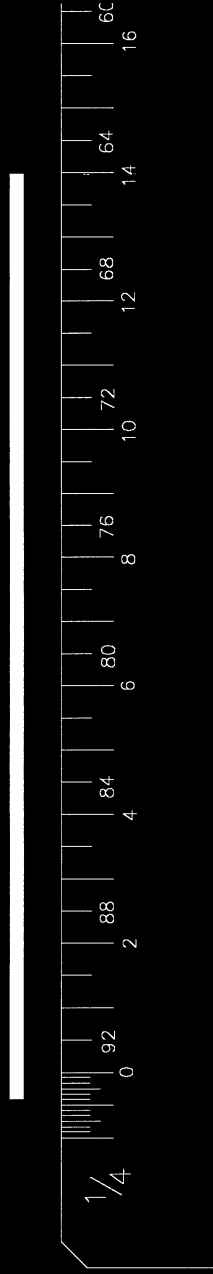
The **_ size Scale** is a mechanical scale. Note that the sub-divided unit is divided into 16 units, a factor of 16, therefore representing fractional parts of an inch. The measured distance is $6-5/8$ inches.

The Engineer's Scale expresses measurements as a ratio, depending on the ratio assigned.



Determine which scale is being used here.

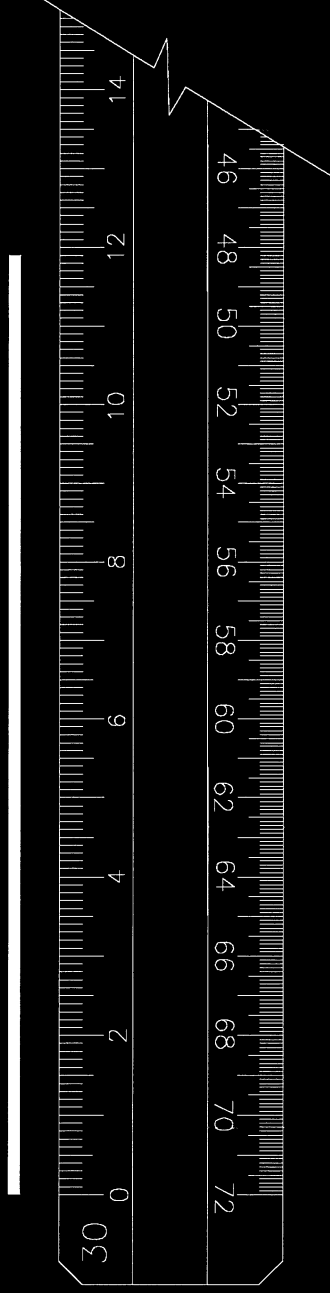
- a. Civil Engineering
- b. Metric
- c. Mechanical
- d. Architectural



Determine the measurement.

Determine which scale is being used here.

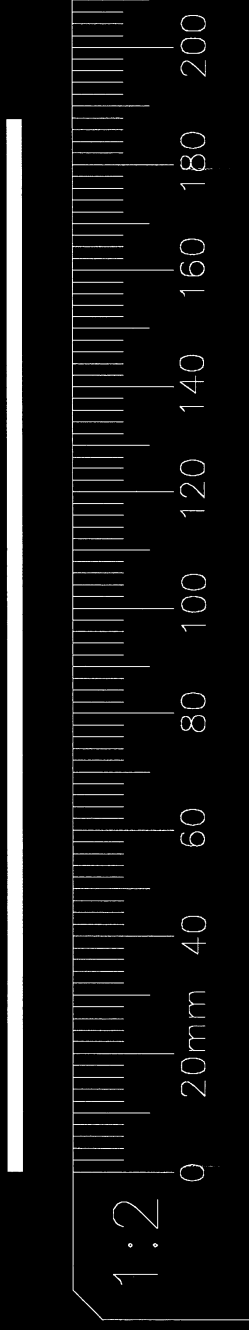
- a. Civil Engineering
- b. Metric
- c. Mechanical
- d. Architectural



Determine the measurement.

Determine which scale is being used here.

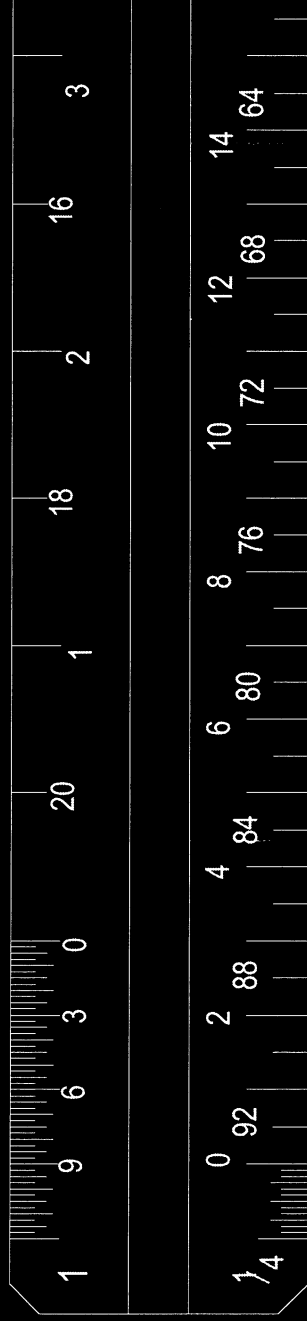
- a. Civil Engineering
- b. Metric
- c. Mechanical
- d. Architectural



Determine the measurement.

Determine which scale is being used here.

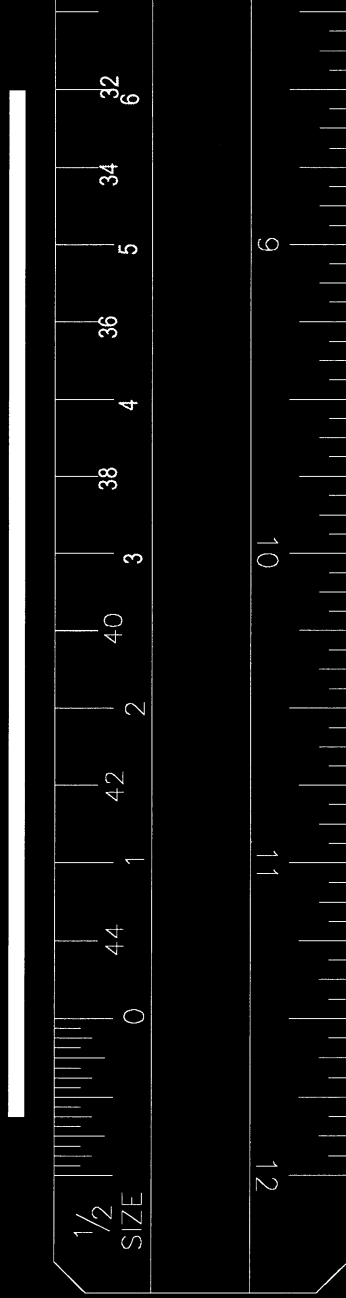
- a. Civil Engineering
- b. Metric
- c. Mechanical
- d. Architectural



Determine the measurement.

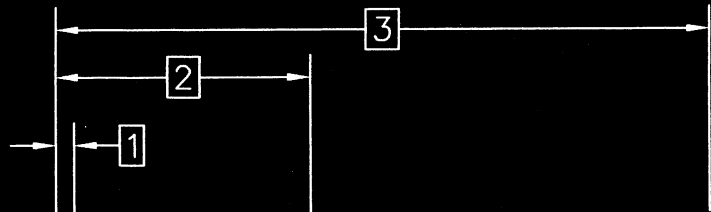
Determine which scale is being used here.

- e. Civil Engineering
- f. Metric
- g. Mechanical
- h. Architectural

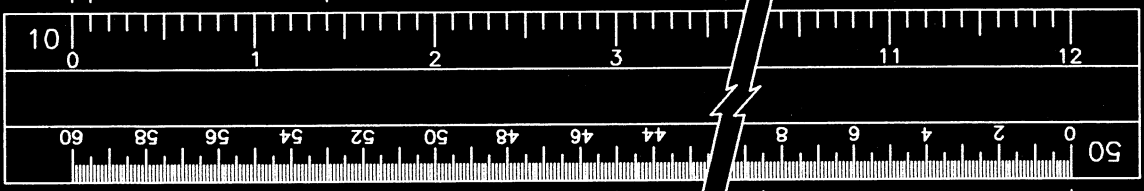


Determine the measurement.

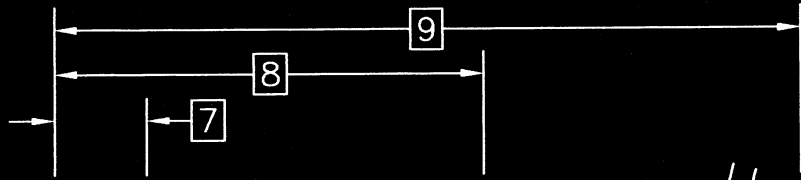
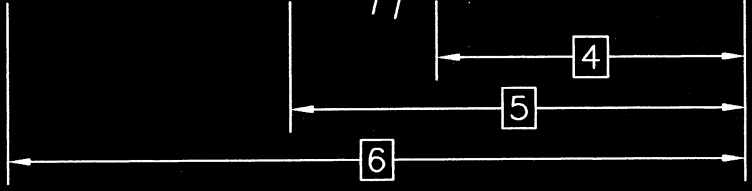
NAME: _____



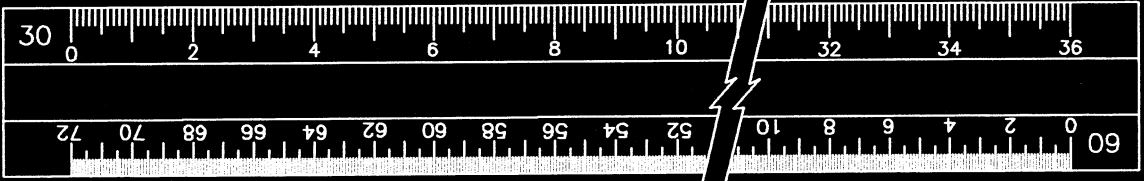
SCALE: 1" = 10'



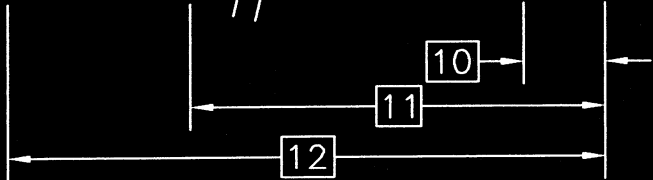
SCALE:
1" = 500'



SCALE:
1" = 3'



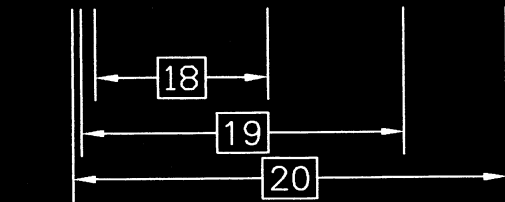
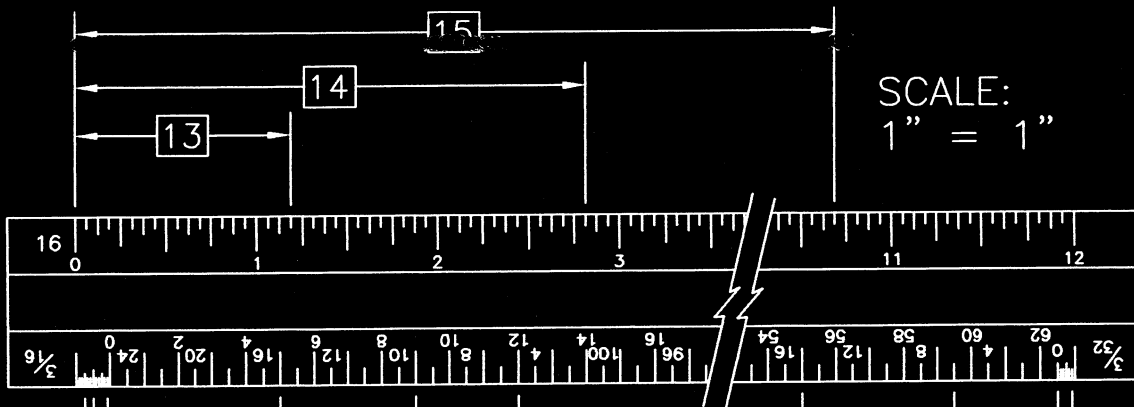
SCALE:
1" = 600'



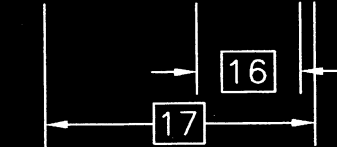
- 1 _____
- 2 _____
- 3 _____
- 4 _____
- 5 _____
- 6 _____

- 7 _____
- 8 _____
- 9 _____
- 10 _____
- 11 _____
- 12 _____

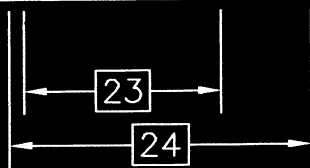
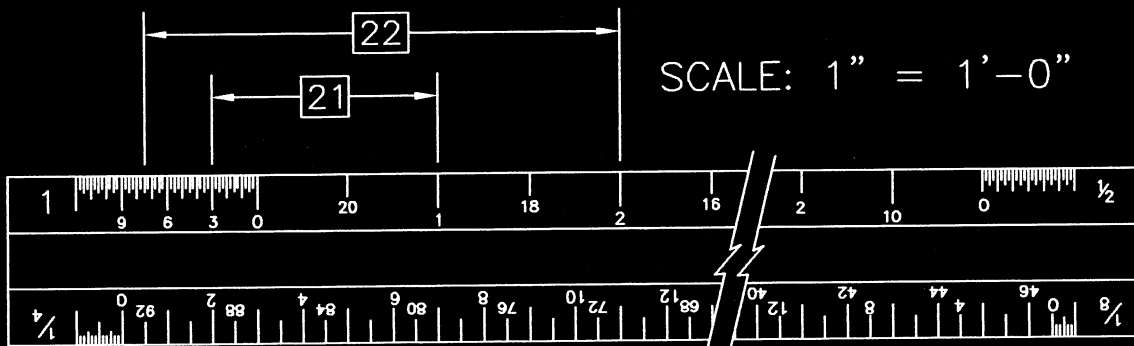
Engineer's Scale



SCALE: $\frac{3}{16}'' = 1'-0''$



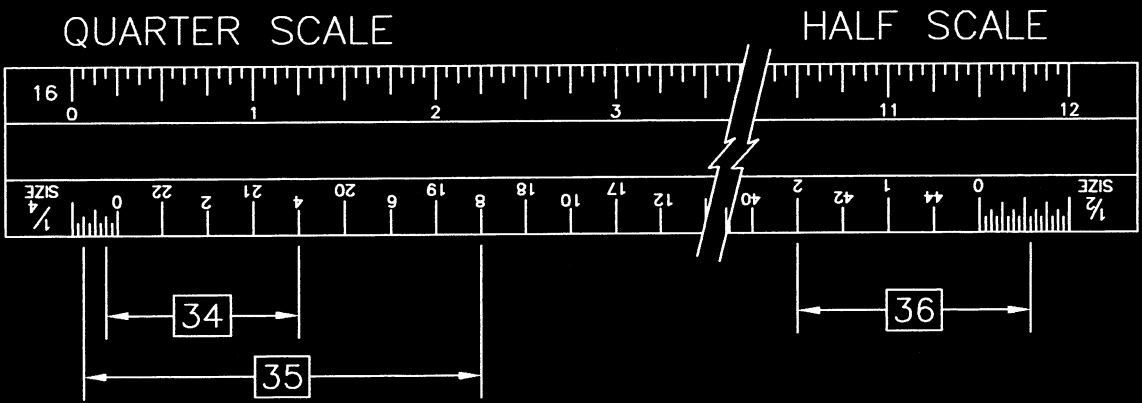
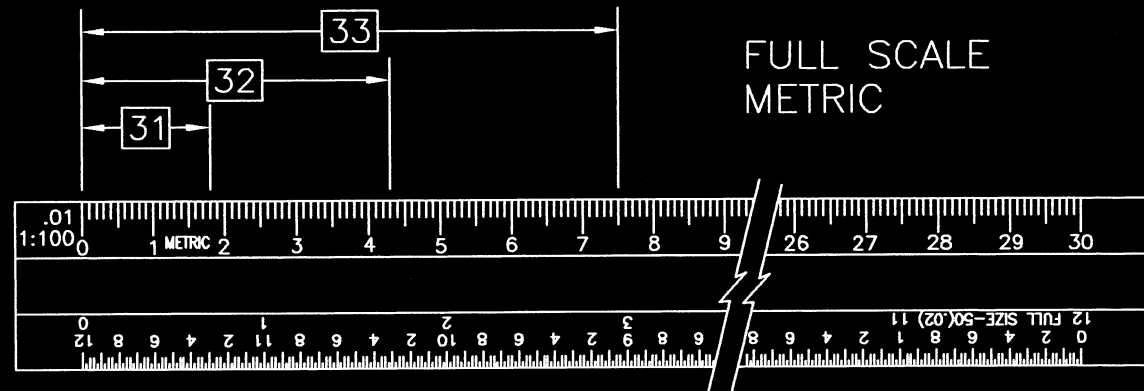
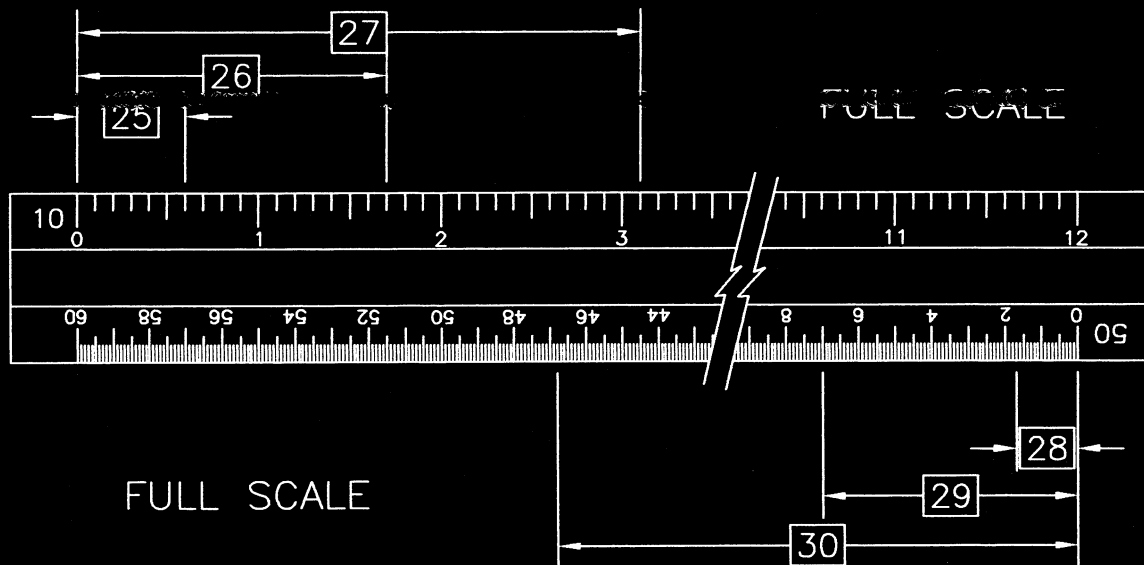
SCALE: $\frac{3}{32}'' = 1'-0''$



SCALE: $\frac{1}{4}'' = 1'-0''$

- | | | | |
|----|-------|----|-------|
| 13 | _____ | 19 | _____ |
| 14 | _____ | 20 | _____ |
| 15 | _____ | 21 | _____ |
| 16 | _____ | 22 | _____ |
| 17 | _____ | 23 | _____ |
| 18 | _____ | 24 | _____ |

Architectural Scales



- 25 _____
- 26 _____
- 27 _____
- 28 _____
- 29 _____
- 30 _____

- 31 _____
- 32 _____
- 33 _____
- 34 _____
- 35 _____
- 36 _____

Combination Mechanical - Engineer's Scale

Answer sheet for Scale Exercise
Engineer's Scale

Scale: 1 = 10

- 1. 1
- 2. 14
- 3. 36

Scale: 1 = 500

- 4. 850
- 5. 4500
- 6. 5280

Scale: 1 = 3

- 7. 1.5
- 8. 7.1
- 9. 31.8

Scale: 1 = 600

- 10. 270
- 11. 5280
- 12. 5860

Architect's Scale

Scale: 1 = 1

- 13. 1 — 3/16
- 14. 4 — 13/16
- 15. 10 — 11/16

Scale: 3/32 = 1 - 0

- 16. 6 - 0
- 17. 15 - 10 ± 1

Scale: 3/16 = 1 - 0

- 18. 5 - 1 ± 1
- 19. 9 - 6
- 20. 12 - 9

Scale: 1 = 1 - 0

- 21. 1 - 3
- 22. 2 - 7 _

Scale: _ = 1 - 0

- 23. 4 - 4
- 24. 6 - 7

Combination Scale

Scale: Full Scale - 10

- 25. 0.6
- 26. 1.7
- 27. 3.1

Scale: Full Scale — 50

- 28. 17/50 inch
- 29. 70/50 = 1-2/5 inches
- 30. 467/50 = 9-17/50 in.

Scale: Full Scale — Metric

- 31. 18mm or 1.8cm
- 32. 43mm
- 33. 75mm

Scale: Quarter Scale

- 34. 4 _
- 35. 8-3/4

Scale: Half Scale

- 36. 2-9/16

Summary of Standard Scales

Architect's Scales Open Divided

Size Ratio	Scale
Full Size	1" = 1"
Quarter Size	3" = 1'-0"
1/8 th Size	1 1/8" = 1'-0"
1/12 th Size	1" = 1'-0"
1/16 th Size	3/8" = 1'-0"
1/24 th Size	1/4" = 1'-0"
1/32 th Size	3/8" = 1'-0"
1/48 th Size	1/4" = 1'-0"
1/64 th Size	3/16" = 1'-0"
1/96 th Size	1/8" = 1'-0"
1/128 th Size	3/32" = 1'-0"

Engineer's Scales Fully Divided

Scale	Uses of Scale
10 scale	each 1" is divided into 10 units. (Used for 1"=1'; 1"=10'; 1"=100'; 1"=1000'; etc)
20 scale	each 1" is divided into 20 units. (Used for 1"=1'; 1"=20'; 1"=200'; 1"=2000'; etc)
30 scale	each 1" is divided into 30 units. (Used for 1"=3'; 1"=30'; 1"=300'; 1"=3000'; etc)
40 scale	each 1" is divided into 40 units. (Used for 1"=4'; 1"=40'; 1"=400'; 1"=4000'; etc)
50 scale	each 1" is divided into 50 units. (Used for 1"=5'; 1"=50'; 1"=500'; 1"=5000'; etc)
60 scale	each 1" is divided into 60 units. (Used for 1"=6'; 1"=60'; 1"=600'; 1"=6000'; etc)

Mechanical Engineer's Scales Usually Open Divided

Size Ratio	Scale
Full Size	1" = 1"
Half Size	1/2" = 1"
Quarter Size	1/4" = 1"
1/8 th Size	1/8" = 1"

Metric Scale Usually Fully Divided

Application	Metric Scale (mm:mm)
Mechanical Drawings	1:1, 1:2, 1:3, 1:5, 1:10
Architectural Details	1:20, 1:25, 1:33
Architectural Plans	1:75, 1:100, 1:200
Civil (Maps) Drawings	1:500, 1:1250, 1:2500, 1:10,000, 1:50,000