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ABSTRACT

This booklet is intended to help mainstreamed mentally retarded, emotionally disturbed, or learning disabled high school students acquire a basic understanding of the responsibilities and working conditions of electricians and to practice basic math skills necessary in the occupation. The first section provides a brief introduction to the occupation by focusing upon those job tasks of a electrician with which the student is likely to be familiar. The next two sections deal with the work environment of the typical electrician and the training, education, and experience needed for the occupation. Exercises addressing basic math skills used by electricians are provided. Various suggestions are listed for students interested in further exploring the occupation of electrician. A glossary and answer sheet conclude the booklet. (YLB)

MATH on the job

Electrician

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MATH ON THE JOB:

ELECTRICIAN

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MATH on the job

Electrician

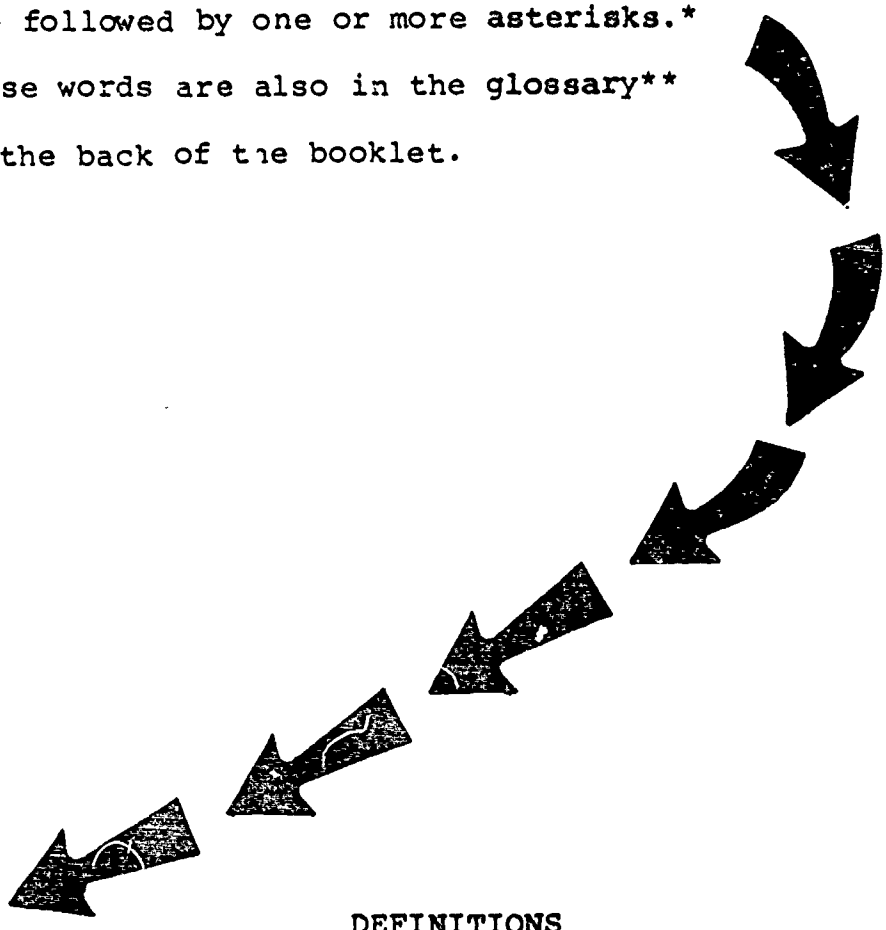
In this booklet, you can--

- find out what an electrician does
- see how an electrician uses math
- get a chance to use math as an electrician
- find out the types of things an electrician needs to know
- find out what courses, training, and experience you need to become an electrician

SPECIAL WORDS USED IN THIS BOOKLET

Workers in many jobs use special words or special meanings for words. Learning these words helps you to learn about a job.

You will find some of these special words in this booklet. When these words, and some hard words, are used for the first time, they are followed by one or more **asterisks.*** These words are also in the **glossary**** at the back of the booklet.



DEFINITIONS

*An asterisk (*) is a symbol that tells you to look at the bottom of the page for the meaning, or definition, of the word.

**A glossary is a list of words with their meanings.

CONTENTS

HAVE YOU EVER...

- felt a shock when you touched someone or touched a light switch?
- changed a light bulb?
- used an extension cord?
- watched the burner coils on an electric stove get red hot when the stove was turned on?
- watched someone wire a lamp or install a switch?

If you have, then you have some idea about the work of an electrician. This booklet will help you learn more about the work of an electrician and how math is important to do the job.

WHAT DOES AN ELECTRICIAN DO?

The main task of an electrician is to install and repair electrical systems. How does an electrician do this? As an electrician, you--

- read blueprints* and written instructions to determine what to do
- assemble the materials needed to do the job
- install interior circuits** and outlets
- measure, cut, and bend electrical conduit***
- pull wiring or cables through the conduit
- connect the wiring or cables to lighting fixtures and power equipment
- test the system to see that the connections are made properly and that the system is working correctly

DEFINITIONS

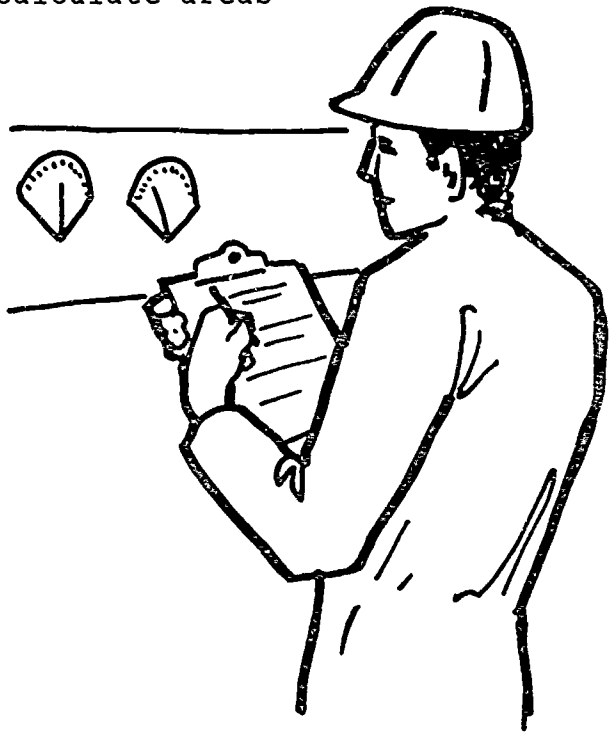
*A blueprint is a hand-drawn picture of how something is to be made or built.

**A circuit is the complete path of wires in which electricity flows.

***Conduit is a pipe, tube, or tile to protect electric wires or cables.

An electrician uses math on the job every day. As an electrician, you will use math to--

- read and write decimals, fractions, and whole numbers
- add, subtract, multiply, and divide
- take measurements
- tell time
- calculate percentages
- read scales or meters
- carefully guess distances
- calculate the electrical load* or capacity**
- calculate areas



DEFINITIONS

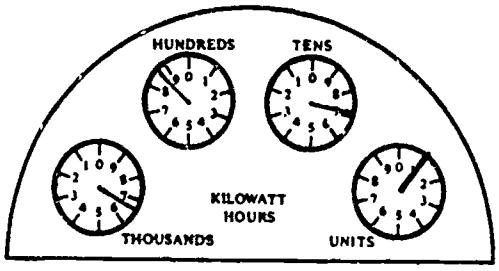
*Load is the amount of use an electrical circuit can handle at one time.

**Capacity is the amount of electricity the wire or system can produce or carry.

An electrician uses math to read meters.

EXAMPLE

The use of electricity is measured in kilowatt hours. Look at the face of the electric meter below.



There are four dials on the meter. The dials are marked THOUSANDS, HUNDREDS, TENS, and UNITS. Notice that the numbers on the HUNDREDS and UNITS dials go clockwise. Notice that the numbers on the THOUSANDS and TENS dials go counterclockwise.

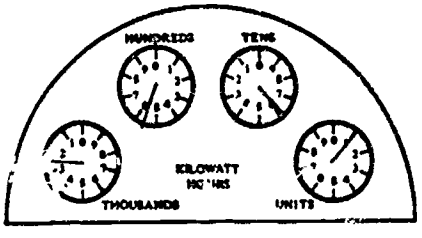
To read the meter, start with the THOUSANDS dial. Read the dials on the meter from left to right. If the needle on a dial face is between two numbers, always read the smaller number. What is the reading on the meter above? You're right if you said 6871 kilowatt hours.

NOW YOU TRY IT

Practice Exercise A

What is the reading on each meter below?

1.



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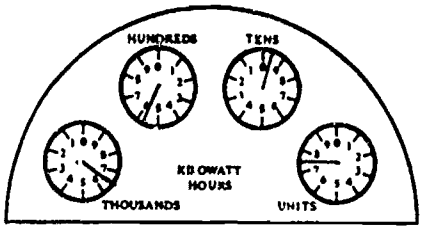

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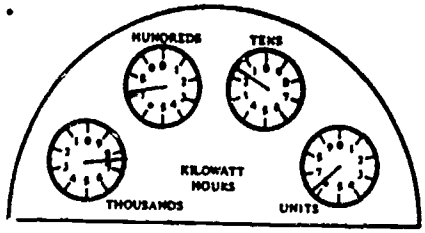


An electrician uses math to select the correct wire size.

EXAMPLE

An electrician must use larger electrical wires for circuits using more current. Electrical wire is made in standard sizes according to the diameter of the wire. The standard sizes are called gauge numbers.

The following table lists some wire sizes by gauge number. Next to each gauge number is the diameter of the wire in millimeters and in mils. A mil is equal to one thousandth of an inch.

Table of Gauge Numbers

Gauge Number	Diameter mm	Diameter mils	Gauge Number	Diameter mm	Diameter mils
0	8.252	324.9	10	2.588	101.90
1	7.348	289.3	11	2.305	90.74
2	6.544	257.6	12	2.053	80.81
3	5.827	229.4	13	1.828	71.96
4	5.189	204.3	14	1.628	64.08
5	4.621	181.9	15	1.450	57.07
6	4.115	162.0	16	1.291	50.82
7	3.665	144.3	17	1.150	45.26
8	3.264	128.5	18	1.024	40.30
9	2.906	114.4	19	0.9116	35.89

If an electrician has some wire that measures 2.053 millimeters in diameter, what gauge is the wire?

According to the table, the wire is 12 gauge.

NOW YOU TRY IT

Practice Exercise B

Use the Table of Gauge Numbers in the example above to complete the following questions.

	Diameter of wire	Gauge number
4.	1.828 mm.	?
5.	3.665 mm.	?
6.	257.6 mils	?
7.	114.4 mils	?
8.	1.024 mm.	?
9.	57.07 mils	?
10.	2.588 mm.	?

An electrician uses math to determine if a meter reading is acceptable.

EXAMPLE

The readings on measuring instruments do not always have to be exact. This allowable difference is called a tolerance. A tolerance often is written as ±%, which means plus or minus a specific percentage of the reading. The reading is acceptable if it falls within this range.

If a desired reading is 75 and the allowable difference or tolerance is ± 15%, what is the allowable range?

Step 1. Find 15% of 75.

$$.15 \times 75 = 11.25$$

Step 2. Round 11.25 to the nearest whole number, 11.

Step 3. Subtract 11 from 75 to find the lower limit.

$$75 - 11 = 64$$

Step 4. Add 11 to 75 to find the upper limit.

$$11 + 75 = 86$$

The allowable range is 64 to 86.

NOW YOU TRY IT

Practice Exercise C

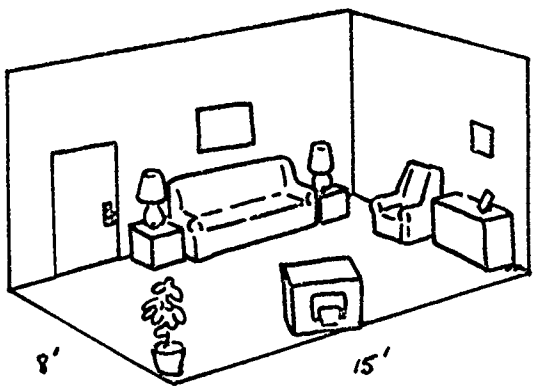
Copy and complete the table below.

	Given Reading	Tolerance	Upper Limit	Lower Limit
11.	119	± 25%	?	?
12.	178	± 13%	?	?
13.	210	± 50%	?	?
14.	134	± 10%	?	?
15.	280	± 5%	?	?
16.	45	+ 10%; -5%	?	?
17.	940	+ 60%; -40%	?	?
18.	612	+ 30%; -10%	?	?
19.	88	+ 12%; -10%	?	?
20.	125	+ 3%; -15%	?	?

An electrician uses math to figure out how much wire is needed.

EXAMPLE

Let's assume that you are an electrician. Your job is to install wiring on all four walls of a room. A sketch of the room is shown below.



In order to determine the least amount of wire needed, you must find the distance around the room. This is called the perimeter. To figure out the perimeter, add the lengths of all four walls. This is the same as adding the length and the width of the room and multiplying the result by two.

For this example, your calculation should look like this:

$$(8' + 15') \times 2 = 46'$$

You need at least 46' of wire.

NOW YOU TRY IT

Practice Exercise D

Copy and complete the table below.

	Length of the Room	Width of the Room	Perimeter
21.	12'	12'	?
22.	15'	10'	?
23.	10'	8'	?
24.	23'6"	17'6"	?
25.	16'3"	13'9"	?

WHERE DOES AN ELECTRICIAN WORK?

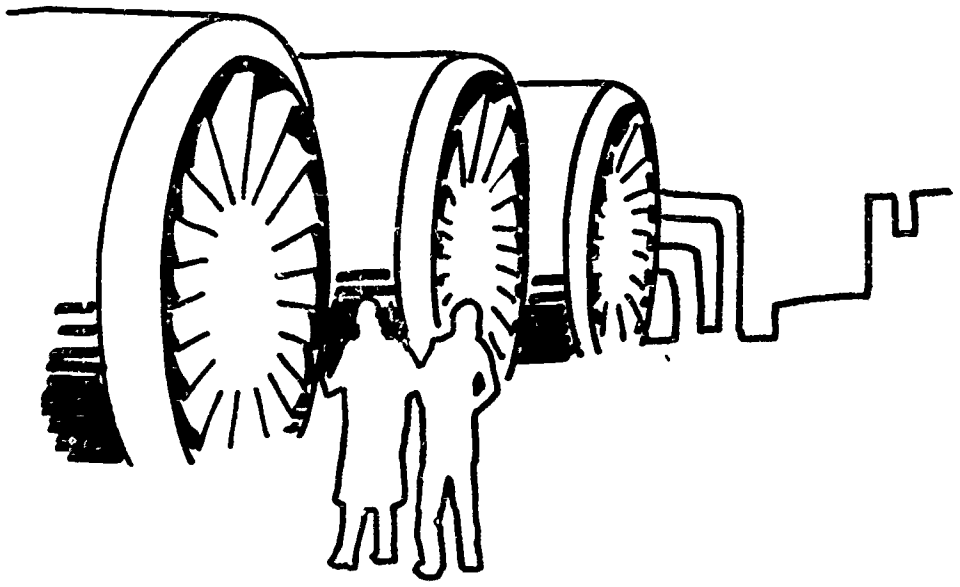
As an electrician, you may be employed by many different types of businesses. You may work for--

- an electrical contractor
- a general contractor
- an industrial plant
- a public utility
- a mining company
- a steel mill
- a manufacturing plant

Where would you like to work?

You will use many tools to do your work. You will use--

- a voltmeter to measure electrical pressure
- an ammeter to measure electrical flow
- continuity testers to determine if a circuit is complete or if there is a break in the circuit



As an electrician, you may install many different types of electrical fixtures. You may install--

- wiring
- switches
- conduit
- fuses
- outlets
- lights
- circuit breakers
- signals
- motors
- large machinery

There are several different types of electricians.

- a construction electrician installs the electrical wiring and fixtures while a building is being built
- a maintenance electrician keeps many different types of electrical equipment in good working order
- a radio electrician installs and repairs high-powered radio transmitting equipment
- an automotive electrician repairs electrical systems in automobiles
- an airplane electrician installs and repairs electrical systems in airplanes

Each type of electrician uses math on the job every day.

IF YOU ARE INTERESTED IN

THE WORK OF AN ELECTRICIAN

AND WOULD LIKE TO KNOW MORE,

READ ON

WHAT TRAINING, EDUCATION, AND EXPERIENCE DO YOU NEED TO BECOME AN ELECTRICIAN?

What do you think? Would you like to be an electrician? If you would, there are some things you should know. You should know--

- how to read blueprints
- safety rules for working with electricity
- how electrical systems work
- the local building rules and regulations for electrical systems

You can learn some of these things while you are in high school. You should take courses in algebra, drafting, physics, electronics, and mechanical drawing.

The best way to become an electrician is to enter an apprenticeship program. To be an apprentice, you should be a high school graduate. You probably will have to take an aptitude test* before you are accepted in the program.

DEFINITION

*An aptitude test is a series of questions that tests your abilities, talents, and interests.

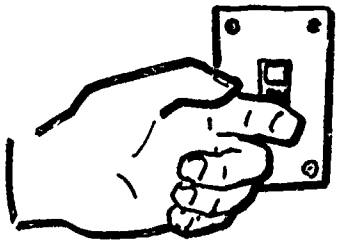
Most apprenticeship programs last four years. In addition to learning while you work on the job, you will have classroom instruction. In the classroom, you will learn about--

- the use, care, and handling of tools and materials
- safety rules
- drafting
- electrical layout
- blueprint reading
- math and electrical theory
- electronics

There are some other ways to learn to be an electrician, such as--

- taking correspondence courses
- taking courses in a vocational education or technical school
- receiving training in the Armed Forces
- working as an electrician's helper

Some experts think you will receive the best training in a shorter amount of time by becoming an apprentice. In many cities, electricians are required to be licensed and must pass a test. Before you enter a training program, you should check out the licensing requirements in your city to make sure your training meets the requirements.

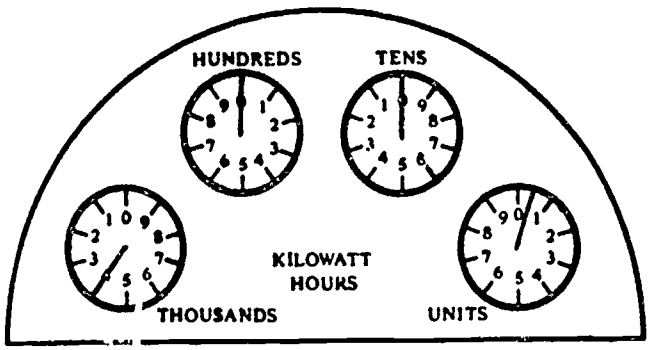


DO YOU WANT TO DO MORE ELECTRICIAN'S MATH?

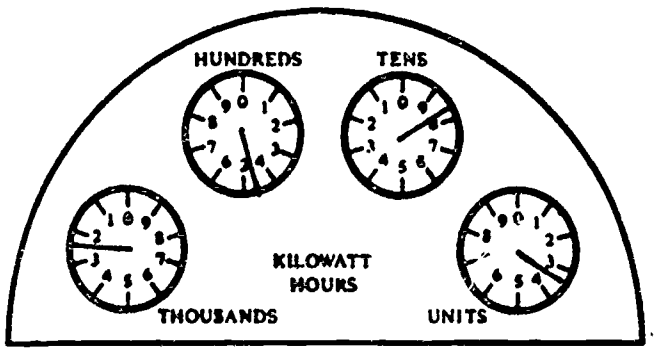
Practice Exercise E

What is the reading on each meter below?

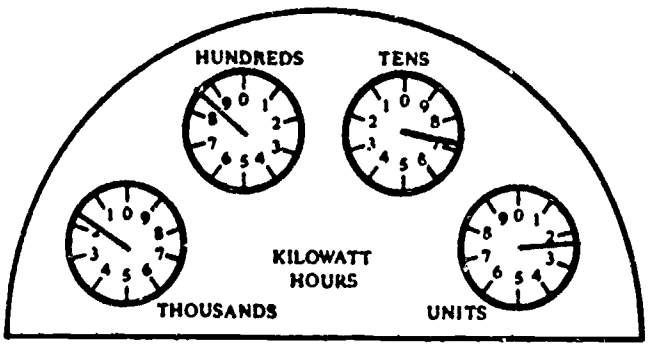
26.



27.



28.



Practice Exercise F

Use this Table of Gauge Numbers to complete the questions which follow.

Table of Gauge Numbers

Gauge Number	Diameter mm	Diameter mils	Gauge Number	Diameter mm	Diameter mils
19	0.9116	35.89	29	0.2859	11.26
20	0.8118	31.96	30	0.2546	10.03
21	0.7230	28.45	31	0.2268	8.928
22	0.6438	25.35	32	0.2019	7.950
23	0.5733	22.57	33	0.1798	7.080
24	0.5106	20.10	34	0.1601	6.305
25	0.4547	17.90	35	0.1426	5.615
26	0.4049	15.94	36	0.1270	5.000
27	0.3606	14.20	37	0.1131	4.453
28	0.3211	12.64	38	0.1007	3.956

	Diameter of Wire	Gauge Number
29.	0.1270 mm.	?
30.	8.928 mils	?
31.	0.4547 mm.	?
32.	14.20 mils	?
33.	0.1007 mm	?

Practice Exercise G

Copy and complete the table below.

	Given Reading	Tolerance	Upper Limit	Lower Limit
34.	360	$\pm$ 25%	?	?
35.	440	$\pm$ 15%	?	?
36.	212	$\pm$ 8%	?	?
37.	70	+ 5%; - 10%	?	?
38.	900	+ 20%; - 15%	?	?
39.	540	+ 15%; - 25%	?	?
40.	155	+ 80%; - 10%	?	?

Practice Exercise H

Copy and complete the table below.

	Length of the Room	Width of the Room	Perimeter
41.	20'	18'	?
42.	62'	55'	?
43.	15'6"	12'8"	?
44.	10'5"	12'3"	?
45.	14'8"	11'3"	?

DO YOU WANT TO EXPLORE SOME MORE?

1. Go to the library and look for a book on remodeling houses. Look in the book for the sections about wiring and making electrical repairs. Read these sections.

2. Ask your guidance counselor for information on vocational programs for electricians. Ask the counselor if you can arrange a visit to the school. Find out how long it would take to complete the program. Find out what types of jobs students get after they finish the program.

3. Contact an electrical contractor or the local union. Find out the requirements to enter the apprenticeship program. Find out what tests you would have to take to become an apprentice.

4. Are you interested in other jobs where you would work with electricity?

   - Electrical-appliance servicers install and repair stoves, refrigerators, dishwashing machines, and other household appliances
   - Elevator constructors assemble and install elevators, escalators, and dumbwaiters
   - Cable television installers install CATV (community antenna television) distribution cables on customers' premises
   - Electric-meter installers install, disconnect, remove, and reconnect electric power meters that record the amount of electricity used
   - Air-conditioning installers install window or central air-conditioning units in homes and small businesses

   You must have good math skills to do these jobs well. Most of these workers use addition, subtraction, multiplication, and division on the job every day.

GLOSSARY

Aptitude test:	a series of questions that tests your abilities, talents, and interests.
Asterisk (*):	a symbol that tells you to look at the bottom of the page for the meaning, or definition, of the word.
Blueprint:	a hand-drawn picture of how something is to be made or built.
Capacity:	the amount of electricity the wire or system can produce or carry.
Circuit:	the complete path of wires in which electricity flows.
Conduit:	a pipe, tube, or tile to protect electric wires or cables.
Glossary:	a list of words with their meanings.
Load:	the amount of use an electrical circuit can handle at one time.

ANSWER SHEET

Practice Exercise A

1. 2561 kilowatt hours
2. 6597 kilowatt hours
3. 7716 kilowatt hours

Practice Exercise B

4. 13
5. 7
6. 2
7. 9
8. 18
9. 15
10. 10

Practice Exercise C

11. 149; 89
12. 201; 155
13. 315; 105
14. 147; 121
15. 294; 266
16. 50; 43
17. 1524; 564
18. 796; 551
19. 99; 79
20. 129; 106

Practice Exercise D

21. 48'
22. 50'
23. 36'
24. 82"
25. 60'

Practice Exercise E

26. 4000 kilowatt hours
27. 2483 kilowatt hours
28. 1872 kilowatt hours

Practice Exercise F

29. 36
30. 31
31. 25
32. 27
33. 38

Practice Exercise G

34. 450; 270
35. 506; 374
36. 229; 195
37. 74; 63
38. 1080; 765
39. 621; 405
40. 279; 140

Practice Exercise H

41. 76'
42. 234'
43. 56'4"
44. 45'4"
45. 51'10"