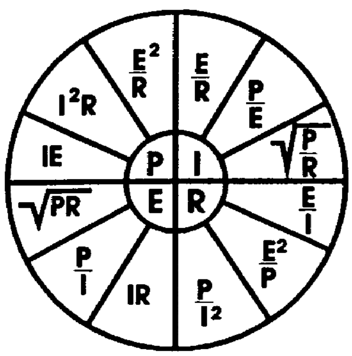
SUBCOURSE
IT 0332

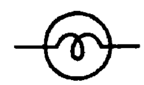
EDITION
A

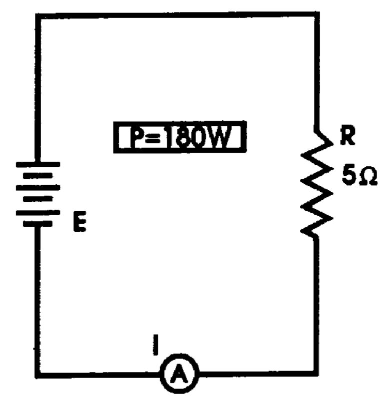
US ARMY INTELLIGENCE CENTER

POWERS OF TEN
AND
CONVERSION OF ELECTRICAL UNITS



$$EFF = \frac{\text{Power converted}}{\text{Power used}}$$





1 Horsepower = 746 Watts

kWh = 1000 watt-hours

THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT
ARMY CORRESPONDENCE COURSE PROGRAM

AIPD
READINESS PROFESSIONALISM THRU GROWTH

POWERS OF TEN AND CONVERSION OF ELECTRICAL UNITS

Subcourse Number IT 0332

Edition A

US ARMY INTELLIGENCE CENTER
FORT HUACHUCA, AZ 85613-6000

2 Credit Hours

EDITION DATE: February 1996

SUBCOURSE OVERVIEW

This subcourse is designed to teach you to use scientific notation, powers of ten, and common number prefixes which denote powers of ten. It will be used throughout the subcourses on electronics.

IT 0332 replaces SA 0700 Powers of Ten and Conversion of Electrical Units.

There are no prerequisites for this subcourse.

TERMINAL LEARNING OBJECTIVE:

ACTION: You will be able to convert numbers between normal notation, powers of ten, and scientific notation; multiply, divide, and find roots of powers of 10; convert numbers expressed by common number prefixes in powers of ten and scientific notation.

CONDITION: Given the information provided in this subcourse.

STANDARD: To demonstrate competency of this task, you must achieve a minimum of 70 percent on the subcourse examination.

TABLE OF CONTENTS

SPECIAL INSTRUCTIONS

1. These lessons contain 62 pages, each of which is divided into one or more frames. Most pages are divided into three frames consisting of:

   a. TOP frame, containing the answer to the PROBLEM in the preceding frame.

   b. A MIDDLE frame, containing an example problem and its solution.

   c. A BOTTOM frame, containing a PROBLEM for you to solve.

2. Do not spend a lot of time solving the problem in the middle frame. The middle frame is meant to be a guide (showing you how to solve different types of problems), so, just examine it carefully step by step until you feel that you understand it. Next, solve the PROBLEM in the bottom frame of the page and, once finished, compare your answer to the correct answer at the top of the next <u>right-hand</u> page. (See the instructions in paragraph 3, below.)

3. This lesson is written in a format which may be unfamiliar to you. To complete this lesson, you must complete the pages and frames in numerical sequence (pages 1-1 through 1-42, pages 2-1 through 2-20; and frames 1 through 138).

LESSON 1

INTRODUCTION TO POWERS OF TEN

Critical Task: None

OVERVIEW

LESSON DESCRIPTION:

Upon completion of this lesson you will be able to convert numbers between normal notation, powers of ten, and scientific notation; multiply, divide, and find roots of powers of 10; convert numbers expressed by common number prefixes in powers of ten and scientific notation.

TERMINAL LEARNING OBJECTIVE:

ACTION: Convert numbers between normal notation, powers of ten, and scientific notation; multiply, divide, and find roots of powers of 10.

CONDITION: Given the information provided in this subcourse.

STANDARD: To demonstrate competency of this task, you must achieve a minimum of 70 percent on the subcourse examination.

INTRODUCTION TO POWERS OF TEN

FRAME
NO. 1

Example of a very large whole number: 100,000,000,000

Example of a very small decimal number: .000000000006

Electrical measurements often involve large whole numbers or small decimal numbers. Working with large whole numbers and small decimal numbers can be time-consuming. Also, using numbers with many zeros may lead to mistakes. Powers of 10 are used to express large whole numbers and small decimal numbers as equivalent numbers containing only a few digits. Obviously, numbers containing fewer digits are easier to use.

Powers of 10 involve the use of exponents. An exponent is a small number written above and to the right of a number which is the base number. The exponent indicates the number of times the base is to be taken as a factor.

For example: $10^3 = 10 \times 10 \times 10 \ \ 1{,}000$.

Multiples of 10, greater than one, can be expressed as the base 10 with a positive exponent.

For example: $10 = 10^1$ $100 = 10^2$ $1{,}000 = 10^3$, etc.

Multiples of 10, between 0 and 1, can be expressed as the base 10 with a negative exponent.

For example: $.1 = 10^{-1}$ $.01 = 10^{-2}$ $.001 = 10^{-3}$, etc.

The base 10, written without an exponent, actually has an exponent of 1.
Thus, $10 = 10^1$.

The base 10, with an exponent of zero, is equal to one. Thus, $10^0 = 1$.

No response required.

FRAME
NO. 2 This table shows some decimals and whole numbers and their equivalent powers of 10. Study it for a moment.

$10{,}000 = 10^4$

$1{,}000 = 10^3$

$100 = 10^2$

$10 = 10^1$

$1 = 10^0$ Notice that $10^0 = 1$

$.1 = 10^{-1}$

$.01 = 10^{-2}$

$.001 = 10^{-3}$

$.0001 = 10^{-4}$

FRAME
No. 3 Any number can be converted into 2 numbers: A <u>number times a power of 10</u>. The number times a power of 10 will have the same digit sequence as the original number. The power of 10 and its sign will be determined by the number of places and the direction the decimal point in the original number is moved.

Examples:	$7{,}900 = 7.9 \text{ X } 10^3$	because	10^3	$= 1{,}000$
	$.01 = 1 \text{ X } 10^{-2}$	"	10^{-2}	$= .01$
	$75 = 7.5 \text{ X } 10^1$	"	10^{-1}	$= 10$
	$.075 = 7.5 \text{ X } 10^{-2}$	"	10^{-2}	$= .01$
	$.075 = 75 \text{ X } 10^{-3}$	"	10^{-3}	$= .001$
	$.075 = 750 \text{ X } 10^{-4}$	"	10^{-4}	$= .0001$

No response required

No response required

FRAME
No. 4 **PROBLEM**:

Fill in the blanks with the equivalent powers of 10.

.0001	=	1	X	10^{-4}	
.001	=	1	X	______	
.01	=	1	X	______	
.1	=	1	X	______	
1	=	1	X	10^{0}	
10	=	1	X	______	
				______	Check your answer with
100	=	1	X	______	the table on page 1-3.
1,000	=	1	X	______	

FRAME
NO. 5 Any number can be converted into 2 numbers: a number times a power of 10. The number times a power of 10 will have the same sequence of digits as the original number. The exponent (power) of the base 10 is always equal to the number of places the decimal point is moved. The exponent is POSITIVE when the decimal point is moved to the LEFT; the exponent is NEGATIVE when the decimal point is moved to the RIGHT.

PROBLEM:

Fill in the blanks: To convert a number to a numerical value times a power of 10, move the decimal point ____________________ to make the power of 10
LEFT/RIGHT
POSITIVE, or move the decimal point _____________ to make the
LEFT/RIGHT
power of 10 NEGATIVE.

FRAME
No. 6

ANSWER:

move the decimal point LEFT: make the power of 10 POSITIVE,

move the decimal point RIGHT: make the power of 10 NEGATIVE.

FRAME
No. 7

Study this problem on equivalent power of 10, then continue.

	.000001 = _________
Rule:	To express a decimal as a whole number times the power of 10, move the decimal point to the RIGHT, count the number of places to the original point, and use this count as a NEGATIVE exponent (or power) of 10.
Solution:	Move the decimal point 6 places to the RIGHT; the exponent is a NEGATIVE 6.
Thus:	$.000001 = 1 \times 10^{-6} = 10^{-6}$

FRAME
No. 8

PROBLEM:

Fill in the blank with the equivalent power of 10.

.001 = ________

FRAME
No. 9

Answer: 10^{-3}
Solution:

Decimal point is moved 3 places to the right; the exponent is a negative 3.

$.001 = 1 \times 10\text{-}3 = 10^{-3}$

FRAME
No. 10

Study this problem on equivalent power of 10, then continue.

100,000,000 = ______

Rule: to express a whole number as a smaller number times a power of 10, move the decimal point to the LEFT, count the number of places to the original point, and use this count as a POSITIVE exponent (or power) of 10.

Solution: Move the decimal point 8 places to the LEFT; the exponent is a POSITIVE 8.

Thus: $100{,}000{,}000 = 1 \times 10^{8} = 10^{8}$

FRAME
NO. 11

PROBLEM:

Fill in the blank with the equivalent power of 10.

1,000 = ______

FRAME
No. 12

ANSWER: 103

Solution:
$1{,}000 = 1 \text{ X } 10^3 = 10^3$

Decimal point is moved 3 places to the LEFT; the exponent is a POSITIVE 3.

FRAME
NO. 13

PROBLEM:

Fill in the blanks with the equivalent powers of 10. Do both problems before checking answers.

100,000 = _____________

.001 = ____________

FRAME
NO. 14 **ANSWER**: 10^5

Solution:
$100,000 = 10^5$ Decimal point is moved 5 places to the LEFT; the exponent is a POSITIVE 5.

ANSWER 10^{-3}

Solution:
$.001 = 10^{-3}$ Decimal point is moved 3 places to RIGHT; the exponent is a NEGATIVE 3.

FRAME
NO. 15 Study the following problem on SCIENTIFIC NOTATION, rounded off to 3 significant digits.

636.42 = ____________________________

Solution: Converting a whole number to SCIENTIFIC NOTATION (a number between 1 and 10 times a power of ten) is done by moving the decimal point LEFT from its position in the original number to a new position which will be immediately following the first significant digit, giving you a POSITIVE power of 10.

NOTE: Count the number of places you moved the decimal point to the LEFT in the original number to its new position following the first significant number. This will give you the proper exponent for your POSITIVE power of 10.

Thus: Original number	In scientific notation, but NOT rounded off.	In scientific notation, and rounded off to 3 significant numbers.

$636.42 = 6.3642 \text{ X } 10^2 = 6.36 \text{ X } 10^2$

FRAME
No. 16 **PROBLEM**:

Convert this number to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

88,885 = ______________________________-

FRAME
No. 17 **ANSWER**: 8.89 X 10^4

Solution: 88,885 = 8.89 X 10^4	8.89 is a number written in SCIENTIFIC NOTATION, a number between 1 and 10 times a power of ten; the decimal point moved four places LEFT; the exponent for the power of 10 is a POSITIVE 4.

FRAME
NO. 18. Study the following problem on SCIENTIFIC NOTATION, rounded off to 3 significant digits.

.0005966 = _________

Solution: Converting a decimal number to SCIENTIFIC NOTATION (a number between 1 and 10 times a power of ten) is done by moving the decimal point RIGHT from its position in the original number to a new position which will be immediately following the first significant digit, giving you a NEGATIVE power of 10.

NOTE: Count the number of places you moved the decimal point to the RIGHT in the original number to its new position following the first significant number. This will give you the proper exponent for your NEGATIVE power of 10.

Thus:

Original number	In scientific notation, but NOT rounded off.	In scientific notation, and rounded off to 3 significant numbers.
.0005966	= 5.966 X 10^4	= 5.97 X 10^4

FRAME
NO. 19 **PROBLEM**:

Convert this number to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

.000088885 = ______________

FRAME
NO. 20 **ANSWER**: 8.89×10^{-5}

Solution:
$.00008885 = 8.89 \times 10^{-5}$

8.89 is a number between 1 and 10;
the decimal point moves RIGHT 5 places;
the exponent is a NEGATIVE 5.

FRAME
NO. 21 Study the following problem on SCIENTIFIC NOTATION, rounded off to 3 significant digits.

45,667 = ____________________

Solution: Place the decimal point between 4 and 5 so the number has a value between 1 and 10. Since the decimal point moved 4 places LEFT, the power of 10 is a POSITIVE 104. Remember, a number in Scientific Notation is a number between 1 and 10 times a power of 10.

Thus: $45{,}667 = 4.5667 \times 10^{4} = 4.57 \times 10^{4}$

FRAME
NO. 22 **PROBLEM**:

Convert this number to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

4,444.3 = _______________

FRAME
NO. 23 **ANSWER:** 4.44×10^3

Solution:
4,444 4.44×10^3

4.44 is between 1 and 10; the decimal point moved 3 places LEFT; the exponent is a +3.

FRAME
NO. 24 Study the following problem on SCIENTIFIC NOTATION, rounded off to 3 significant digits.

665,878 = ___________

Solution: 6.65878 is a number between 1 and 10. Since the decimal point moved 5 places LEFT, the exponent of the power of 10 is a POSITIVE 5. 6.65878 is now 6.66 rounded off to 3 significant digits.

Thus: $665{,}878 = 6.65878 \times 10^5 = 6.66 \times 10^5$

FRAME
NO. 25 **PROBLEM**:

Convert this number to SCIENTIFIC NOTATION, rounded off to 3 significant digits.

.00008887 = ______________

FRAME
NO. 26 **ANSWER**: 8.89 X 10^{-5}

Solution: .00008887 = 8.887 X 10^{-5} = 8.89 X 10^{-5}

FRAME
NO. 27 **PROBLEM**:

Convert this number to SCIENTIFIC NOTATION, rounded off to 3 significant digits, times the proper power of 10. Do both problems before checking answers.

.000034567 = ________________

881.238 = ________________

FRAME
NO. 28

ANSWER: 3.46×10^{-5}

Solution: $.000034567 = 3.46 \times 10^{-5}$

ANSWER: 8.81×10^{2}

Solution: $881.238 = 8.81 \times 10^{2}$

FRAME
NO. 29

Study the problems below, then continue.

$3{,}200 = \_\_\_\_\_ \times 10^{4}$

$3{,}200 = \_\_\_\_\_ \times 10^{-4}$

Solution: Move the decimal point to the LEFT when the exponent is POSITIVE; and to the RIGHT when the exponent is NEGATIVE.

Thus: $3{,}200 = .3200 \times 10^{4}$

$3{,}200 = 32{,}000{,}000 \times 10^{-4}$

FRAME
NO. 30

PROBLEM:

Fill in the blank with the proper numerical value.

$50{,}000 = \_\_\_\_\_ \times 10^{7}$

FRAME
NO. 31 **ANSWER**: .005

Solution:
$50,000 = .005 \times 10^7$

The decimal point moves 7 places LEFT when the exponent is a +7.

FRAME
NO. 32 Study the problem below, then continue.

$.000000000045 = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \times 10^{-12}$

Solution: Move the decimal point 12 places RIGHT when the exponent is a NEGATIVE 12.

Thus: $.000000000045 = 45 \times 10^{-12}$

FRAME
NO. 33 **PROBLEM**:

Fill in the blank with the proper value.

$.00056 = \_\_\_\_\_\_\_\_\_\_\_\_ \times 10^{-6}$

FRAME
NO. 34 **ANSWER**: 560

Solution: Exponent is a NEGATIVE 6; the decimal point
$.00056 = 560 \times 10^{-6}$ moves 6 places to the RIGHT.

FRAME
NO. 35 Study the problem below, then continue.

.1 = ______________________

Solution: Move decimal point one place to the right; the exponent is a NEGATIVE one.

Thus: $.1 = 1 \times 10^{-1} = 10^{-1}$

FRAME
NO. 36 **PROBLEM**:

Fill in the blank with the equivalent power of 10.

.00000001 = 1 X ______ = _____

FRAME
NO. 37 **ANSWER**: 10^{-8}

Solution:
$.00000001 = 1 \times 10^{-8} = 10^{-8}$

Exponent is a NEGATIVE 8 when the decimal point moves 8 places to the RIGHT.

FRAME
NO. 38 Study the problems below, then continue.

$9.15 \times 10^{3} =$ ________ $\times 10^{6}$

$9.15 \times 10^{-3} =$ ________ $\times 10^{-6}$

Solution: Move the decimal point to the LEFT when the change in exponent is in a POSITIVE direction. Move the decimal point to the RIGHT when the change in exponent is in a NEGATIVE direction.

Thus: $9.15 \times 10^{3} = .00915 \times 10^{6}$

$9.15 \times 10^{-3} = 9{,}150 \times 10^{-6}$

NOTE: Changing from 10^{3} to 10^{6} means the exponent changes by 3 in a POSITIVE direction. Changing form 10^{-3} to 10^{-6} means the exponent changes by 3 in a NEGATIVE direction.

FRAME
NO. 39 **PROBLEM**:

Fill in the blank with the proper value.

$2.2 \times 10^{-2} =$ ______ $\times 10^{0}$

FRAME
NO. 40 **ANSWER**: .022

Solution: $2.2 \times 10^{-2} = .022 \times 10^{0}$

Changing from 10^{-2} to 10^{0} means the exponent changes by 2 in a POSITIVE direction; so the decimal point moves 2 places to the LEFT.

FRAME
NO. 41 **PROBLEM**:

Study the problem below, then continue.

$3.33 \times 10^{-4} =$ ____________________________ $\times 10^{-6}$

Solution: Changing from 10^{-4} to 10^{-6} means the exponent changes by 2 in a NEGATIVE direction; so the decimal point in 3.33 moves 2 places to the RIGHT.

Thus: $3.33 \times 10^{-4} = 333 \times 10^{-6}$

FRAME
NO. 42 **PROBLEM**:

Fill in the blank with the proper value.

$5.83 \times 10^{2} =$ _____ $\times 10^{-1}$

FRAME
NO. 43 **ANSWER**: 5,830

Solution: $5.83 \times 10^{2} = 5{,}830 \times 10^{-1}$	Changing from 10^{2} to 10^{-1} means the exponent changes by 3 in a NEGATIVE direction; so the decimal point in 5.83 moves 3 places to the RIGHT.

FRAME
NO. 44 Study the problem below, then continue.

$250{,}000 = \_\_\_\_\_\_ \times 10^{5}$

Solution: Move the decimal point 5 places to the LEFT when the exponent is a POSITIVE 5.

Thus: $250{,}000 = 2.5 \times 10^{5}$

FRAME
NO. 45 **PROBLEM**:

Fill in the blank with the proper value.

$13{,}460 = \_\_\_\_\_\_ \times 10^{-12}$

FRAME
NO. 46 **ANSWER**: 13,460,000,000,000,000

Solution:
$13,460 = 13,460,000,000,000,000 \times 10^{-12}$

When the exponent is a NEGATIVE 12, the decimal point is moved 12 places to the RIGHT.

FRAME
NO. 47 Study the problem below, then continue.

$6.660 \times 10^{-4} =$ ________________________ $\times 10^{-7}$

Solution: Changing from 10^{-4} to 10^{-7} means the exponent changes by 3 in a NEGATIVE direction; so the decimal point in the original number 6.660 moves 3 places to the RIGHT.

Thus: $6.660 \times 10^{-4} = 6,660 \times 10^{-7}$

FRAME
NO. 48 PROBLEM:

Fill in the blank with the proper value.

$7.09 \times 10^{4} =$ ____________________ $\times 10^{-1}$

FRAME
NO. 49 **ANSWER**: **709,000**

SOLUTION:

$7.09 \times 10^4 = 709{,}000 \times 10^{-1}$ Changing from 10^4 to 10^{-1} means the exponent changes by 5 in a NEGATIVE direction; so the decimal point in 7.09 moves 5 places to the right.

FRAME
NO. 50 **PROBLEM**:

Fill in the blanks with the proper values. Do both problems before checking answers.

83,000 = ________________ X 10^6

.0000525 ________________ X 10^{-12}

FRAME
NO. 51 **ANSWER**: .083

Solution:
$83{,}000 = .083 \times 10^{6}$

POSITIVE 6 exponent; decimal point moves 6 places to the LEFT.

ANSWER: 52,500,000

Solution:
$.0000525 = 52{,}500{,}000 \times 10^{-12}$

NEGATIVE 12 exponent; decimal point moves 12 places to the RIGHT

FRAME
NO. 52 **PROBLEM**:

Fill in the blanks with the proper values

$4.24 \times 10^{-6} =$ ____________________ $\times 10^{-3}$

$6.28 \times 10^{4} =$ _____________________ $\times 10^{-2}$

FRAME
NO. 53 **ANSWER: .00424**

Solution:
$4.24 \times 10^{-6} = .00424 \times 10^{-3}$

ANSWER: 6,280,000

Solution:
$6.28 \times 10^{4} - 6,280,000 \times 10^{-2}$

Changing from 10^{-6} to 10^{-3} means the exponent changes by 3 in a POSITIVE direction; so the decimal point in 4.24 moves 3 places to the LEFT. Changing from 10^{4} to 10^{-2} means the exponent changes by 6 in a NEGATIVE direction; so the decimal point in 6.28 moves 6 places to the RIGHT.

FRAME
NO. 54 Powers of 10 simplify problem solving. For example:

Multiplication: $2,000 \times 45,000 = (2 \times 10^{3}) \times (4.5 \times 10^{4}) =$
9X 107

Division: $\frac{66.000}{3,000} = \frac{6.6 \times 10^{4}}{3 \times 10^{3}} = \frac{6.6 \times 10^{4} \times 10^{-3}}{3} = 2.2 \times 10^{1}$ or 22

Extracting square root:

$\sqrt{4,000,000} = \sqrt{4 \times 10^{6}} = 2 \times 10^{6+2} = 2 \times 10^{3}$

Squaring a number: $(20,000)^{2} = (2 \times 10^{4})^{2} = 4 \times 10^{4x2} = 4 \times 10^{8}$

Study the examples above for a moment.

No response required

FRAME
NO. 55 Study the problems below, then continue.

10,000 X 100	=	________________
·0000001 X .001	=	________________
10,000 X .001	=	________________
23,000 X 500	=	________________
6,200 X .02.X 2,000	=	________________

Solution: To MULTIPLY two or more numbers using powers of 10, ADD the EXPONENTS (power) and retain the base 10.

Thus:
10,000 X 100 = 1 X 10^{4+2} = 10^{6}

.0000061 X .001 = 1 X $10^{-7+(-3)}$ = 10^{-10}

10,000 X .001 = 1 X $10^{4+(-3)}$ = 10^{1}

23,000 X 500 = 2.3 X 10^{4} X 5 X 10^{2} = 11.5 X 10^{4+2} = 11.5 X 10^{4+2}
= 11.5 X 10^{6}

6,200 X .02 X 2,000 = 6.2 X 10^{3} X 2 X 10^{-2} X 2 X 10^{3}

= 24.8 X $10^{3+(-2)+3}$ = 24.8 X 10^{4}

FRAME
NO. 56 **PROBLEM**:

Solve using powers of 10.

(1 X 10^{6})(1 X 10^{3})(1 X 10^{-3})(1 X 10^{6}) =

FRAME
NO. 57 **ANSWER**: 10^{12}

Solution:
$10^6 \times 10^3 \times 10^{-3} \times 10^6$
$= 10^{6+3+(-3)+6} = 10^{12}$

To multiply powers of 10, add exponents and retain the base 10.

Study the problem below, then continue.

300 X 2,200 X .001 =

Solution: To multiply, convert each number to SQENTIFIC NOTATION; multiply the numerical values together and add the exponents (powers of 10).

Thus:

$300 \times 2{,}200 \times .001 = (3 \times 10^2) \times (2.2 \times 10^3) \times (1 \times 10^{-3})$
$= 3 \times 2.2 \times 10^{2+3+(-3)} = 6.6 \times 10^2$

FRAME
NO. 58 **PROBLEM**:

Solve using powers of 10.

3,500 X .0035 X 8,000 =

FRAME
NO. 59 **ANSWER**: 98 X 10^3 or 9.8 X 10^4

Solution:
3,500 X .0035 X 8,000 = (3.5 X 10^3) X (3.5 X 10^{-3}) X (8 X 10^3)

= (3.5 X 3.5 X 8) X $10^{3+(-3)+3}$

= 98 X 10^3 or 9.8 X 10^4

FRAME
NO. 60 Study the problem below, then continue.

$$\frac{10^7}{10^3} =$$

Solution: To DIVIDE, move 10^3 from the denominator to the numerator; CHANGE the SIGN OF THE EXPONENT 3, then add the exponents.

Thus: $$\frac{10^7}{10^3} = \frac{10^7 \text{ X } 10^{-3}}{1} = 10^{7+(-3)} = 10^4$$

FRAME
NO. 61 **PROBLEM**:

Solve using powers of 10.

$$\frac{660.000}{.0002} = \underline{\qquad\qquad}$$

FRAME
NO. 62 **ANSWER**: 3.3×10^9

Solution:

$$\frac{660.000}{.0002} = \frac{6.6 \times 10^5}{2 \times 10^{-4}} = \times \frac{6.6 \times 10^5 \times 10^4}{2} = 3.3 \times 10^9$$

FRAME
NO. 63 Study the problem below, then continue.

$$\frac{66.000}{.000003} =$$

Solution: Convert to SCIENTIFIC NOTATION (or small, easy-to-divide numbers); then divide, using laws of exponents.

Thus: $$\frac{66.000}{.000003} = \frac{6.6 \times 10^4}{3 \times 10^{-6}} = \frac{6.6 \times 10^4 \times 10^6}{3} = 2.2 \times 10^{10}$$

FRAME
NO. 64 **PROBLEM**:

Solve using powers of 10.

$$\frac{45.000.000}{.005} = \underline{\hspace{4cm}}$$

FRAME
NO. 65 **ANSWER**: 9×10^9

Solution:

$$\frac{45.000.000}{.005} = \frac{4.5 \times 10^7}{5 \times 10^{-3}} = \frac{4.5 \times 10^7 \times 10^3}{5} = .9 \times 10^{10} \text{ or } 9 \times 10^9$$

FRAME
NO. 66 Study the problem below, then continue.

.00006 X .144 X .02 =

Solution: Convert the numbers to SCIENTIFIC NOTATION; multiply the numerical values and add the exponents (powers of 10).

Thus:

$$.00006 \times .144 \times .02 = (6 \times 10^{-5}) \times (1.44 \times 10^{-1}) \times (2 \times 10^{-2})$$
$$= (6 \times 1.44 \times 2) \times 10^{-5+(-1)+(-2)} = 17.28 \times 10^{-8}$$

FRAME
NO. 67 **PROBLEM**:

Solve using powers of 10.

1,200 X 200 X .0003 =

FRAME
NO. 68 **ANSWER**: 7.2×10^1

Solution:
$1{,}200 \text{ X } 200 \text{ X } .0003 = (1.2 \text{ X } 10^3) \text{ X } (2 \text{ X } 10^2) \text{ X } (3 \text{ X } 10^4)$

$= (1.2 \text{ X } 2 \text{ X } 3) \text{ X } 10^{3+2+(-4)}$

$= 7.2 \text{ X } 10^1$

FRAME
NO. 69 **Study the problem below, then continue**.

$(10^4)^2 =$

Solution: To raise a power of 10 to the second power, MULTIPLY the power of 10 by 2.

Thus: $(10^4)^2 = 10^{4 \text{X} 2} = 10^8$

FRAME
NO. 70 **PROBLEM**:

Solve using powers of 10.

$(10^6)^2 =$

FRAME
NO. 71 **ANSWER**: 10^{12}

Solution: $(10^6)^2 = 10^{6X2} = 10^{12}$

FRAME
NO. 72 Study the problem below, then continue.

$(30{,}000)^2 =$

Solution: Convert to SCIENTIFIC NOTATION; Square the numerical Value And Multiply the power of 10 by the exponent 2.

Thus: $(30{,}000)^2 = (3X10^4)^2 = 32 \text{ X } 10^{4x2} = 9 \text{ X } 10^8$

FRAME
NO. 73 Problem:

Solve using powers of 10.

$(6X10^3)^2 =$

FRAME
NO. 74 **ANSWER**: 36×10^6 or 3.6×10^7

Solution $(6 \times 10^3)^2 = 6^2 \times 10^{3 \times 2} = 36 \times 10^6$ or 3.6×10^7

FRAME
NO. 75 Study the problem below, then continue.

$$\frac{.159}{.00003} =$$

Solution: Convert to easily divisible numbers times powers of 10; then divide.

Thus: $$\frac{.159}{.00003} = \frac{159 \times 10^{-3}}{3 \times 10^{-5}} = \frac{159 \times 10^{-3} \times 10^{5}}{3} = 53 \times 10^2$$

FRAME
NO. 76 **PROBLEM**:

Solve using powers of 10.

$$\frac{1}{.000005} =$$

FRAME
NO. 77 **ANSWER**: $2X10^5$

Solution: $\dfrac{1}{.000005} = \dfrac{1}{5 X 10^{-6}} = \dfrac{1 X 10^6}{5} = \dfrac{10 X 10^5}{5} = 2 X 10^5$

NOTE: By converting $1 X 10^6$ to $10 X 10^5$, it becomes easier to divide by 5.

FRAME
NO. 78 **PROBLEM**:

Solve using powers of 10. Do both problems before checking answers.

$10^7 X 5 X 10^{-2} X 10^6 =$

$.225 X .002 X .04 =$

FRAME
NO. 79 **ANSWER**: 5×10^{11}

Solution: $10^7 \times 5 \times 10^{-2} \times 10^6 = 5 \times 10^{7+(-2)+6} = 5 \times 10^{11}$

ANSWER: 18×10^{-6} or 1.8×10^{-5}

Solution:
$.225 \times .002 \times .04 = (2.25 \times 10^{-1}) \times (2 \times 10^{-3}) \times (4 \times 10^{-2})$
$= 18 \times 10^{-6}$ or 1.8×10^{-5}

FRAME
NO. 80 Study the problem below, then continue.

$$\sqrt{10^8} =$$

Solution: To extract the SQUARE ROOT of a power of 10, DIVIDE the EXPONENT by 2, and retain the base 10.

Thus: $\sqrt{10^8} = 10^{8 \div 2} = 10^4$

FRAME
No. 81 **PROBLEM**:

Solve using powers of 10.

$$\sqrt{10^6} =$$

FRAME
NO. 82 **ANSWER**: 10^3

Solution:

$$\sqrt{10^6} = 10^{6 \div 2} = 10^3$$

FRAME
NO. 83 Study the problem below, then continue.

$$\sqrt{30 \text{ X } 20 \text{ X } 2 \text{ X } 3 \text{ X } 10^2} =$$

Solution: Combine and convert the numbers under the radical sign into 2 numbers, a numerical value and an "EVEN" power of 10. By even, we mean that the power can be divided evenly by 2.

THUS:

$$\sqrt{30 \text{ X } 20 \text{ X } 2 \text{ X } 3 \text{ X } 10^2} = \sqrt{3{,}600 \text{ X } 10^2}$$

$$= \sqrt{36 \text{ X } 10^2 \text{ X } 10^2}$$

$$= \sqrt{36 \text{ X } 10^4}$$

$$= 6 \text{ X } 10^{4 \div 2} = 6 \text{ X } 10^2$$

FRAME
NO. 84 **PROBLEM**:

Solve using powers of 10.

$$\sqrt{1{,}000 \text{ X } 10^7} =$$

FRAME
NO. 85 **ANSWER**: 10^5

Solution:

$$\sqrt{1{,}000 \text{ X } 10^7} = \sqrt{10^3 \text{ X } 10^7} = \sqrt{10^{10}} = 10^{10 \div 2} = 10^5$$

FRAME
NO. 86 Study the problem below, then continue.

$(400 \text{ X } 10^4)^2 =$

Solution: Convert quantity in parentheses to SCIENTIFIC NOTATION; square the numerical value; multiply the power of 10 by 2.

Thus: $(400 \text{ X } 10^4)^2 = (4 \text{ X } 10^2 \text{ X } 10^4)^2 =$
$4^2 \text{ X } 10^{6\text{X}2} = 16 \text{ X } 10^{12}$ or $1.6 \text{ X } 10^{13}$

FRAME
NO. 87 **PROBLEM**:

Solve using powers of 10.

$(12 \text{ X } 10^{-3})^2 =$

FRAME
NO. 88 **ANSWER**: 144×10^{-6} or 1.44×10^{-4}

Solution:
$(12 \times 10^{-3})^2 = 12^2 \times 10^{-3x2} = 144 \times 10^{-6}$ or 1.44×10^{-4}

FRAME
NO. 89 **PROBLEM**:

Solve using powers of 10. Do both problems before checking answers.

$$\frac{1}{500{,}000} =$$

$$\frac{10^8 \times 10}{10^{-5} \times 1{,}000} =$$

FRAME
NO. 90 **ANSWER**: 2×10^{-6}

Solution:

$$\frac{1}{500{,}000} = \frac{10 \times 10^{-1}}{5 \times 10^{-5}} = \frac{10}{5} \times 10^{-8} = 2 \times 10^{-6}$$

ANSWER: 10^{11}

Solution:

$$\frac{1 \times 10^{9}}{1 \times 10^{-5} \times 10^{3}} = 10^{9} \times 10^{5} \times 10^{-3} = 10^{11}$$

FRAME
NO. 91 Study the problem below, then continue.

$$\sqrt{81{,}000 \times 10^{3}} =$$

Solution: Convert the numbers under the radical sign to a numerical value times an "EVEN" power of 10 (divisible by 2). If it is not EVEN, it must be made EVEN.

Thus:

$$\sqrt{81{,}000 \times 10^{3}} = \sqrt{81 \times 10^{3} \times 10^{3}}$$

$$= \sqrt{81 \times 10^{6}}$$

$$= 9 \times 10^{6 \quad 2} = 9 \times 10^{3}$$

FRAME
NO. 92 **PROBLEM**:

Solve using powers of 10.

$$\sqrt{2{,}500 \times 10^{4}} =$$

FRAME
NO. 93 **ANSWER**: 5×10^3

Solution:

$$\sqrt{2{,}500 \times 10^4} = \sqrt{25 \times 10^2 \times 10^4} = \sqrt{25 \times 10^6} =$$

$$5 \times 10^{6 \div 2} = 5 \times 10^3$$

FRAME
NO. 94 **PROBLEM**:

Solve using powers of 10. Do both problems before checking answers.

$(100 \times 10{,}000)^2 =$

$(3 \times 10^5)^2 =$

FRAME
NO. 95 **ANSWER**: 10^{12}

Solution:
$(100 \times 10{,}000)^2 = (10^2 \times 10^4)^2 = (10^6)^2 = 10^{6x2} = 10^{12}$

ANSWER: 9×10^{10}

Solution: $(3 \times 10^5)2 = 3^2 \times 10^{5X2} = 9 \times 10^{10}$

FRAME
NO. 96 **PROBLEM**:

Solve using powers of 10. Do both problems before checking answers.

$$\sqrt{4 \times 3 \times 12 \times 10^4} =$$

$$\sqrt{160 \times 10^5} =$$

FRAME
NO. 97 **ANSWER**: 12×10^2 or 1.2×10^3

Solution:

$$\sqrt{4 \times 3 \times 12 \times 10^4} = \sqrt{144 \times 10^4} = 12 \times 10^2 \text{ OR } 1.2 \times 10^3$$

ANSWER: 4×10^3

Solution:

$$\sqrt{160 \times 10^5} = \sqrt{16 \times 10^6} = 4 \times 10^3$$

FRAME
NO. 98 Electrical and electronic problems are often combinations of multiplication, division, and extracting square roots. It is suggested that combination problems be solved in this order:

(1) Convert all numbers to SCIENTIFIC NOTATION, or to small, easy-to-handle numbers; multiply by the proper powers of 10.

(2) Extract square roots (thus removing the radical signs).

(3) Multiply, divide, etc., until solution is reached. Study the above information, then continue below.

FRAME
NO. 99 **PROBLEM**:

Fill in the blanks:

To extract the square root of a power of 10, the power of 10 must be _______.
odd/even

If it is not _______, it must be made _______.
odd/even odd/even

NO. 100 **ANSWERS**: even, even, even

INTRODUCTION TO CONVERSION OF ELECTRICAL UNITS

CRITICAL TASK: None

OVERVIEW

LESSON DESCRIPTION:

Upon completion of this lesson, you will be able to convert numbers expressed by common number prefixes in powers of ten and scientific notation.

TERMINAL LEARNING OBJECTIVE:

ACTION:	Convert numbers expressed by common number prefixes in powers of 10 and scientific notation.
CONDITION:	Given the information provided in this subcourse.
STANDARD:	To demonstrate competency of this task, you must achieve a minimum of 70 percent on the subcourse examination.

NO 101 **INTRODUCTION TO CONVERSION OF ELECTRICAL UNITS**

The volt, the ohm, and the ampere are the basic units of electrical measurements. You previously learned that one ampere of current flows through one ohm of resistance when one volt of electrical force is applied across the resistance.

Often, the unit of measurement (volt, ohm, and ampere) is expressed with a prefix to enable the handling of extremely large or extremely small electrical measurements. For example, electrical values expressed in basic units, such as 40,000 volts and .005 ampere, could be expressed in units with prefixes, such as 40 kilovolts and 5 milliamperes.

Thus, it can be seen that any unit of electrical measurement can be expressed with or without a prefix.

No response required

FRAME
NO. 102 There are 5 metric prefixes commonly used with electrical measurements; these are: mega, kilo, milli, micro, and pico.

(1) Mega, abbreviated M, means million. Since 1,000,000 can be expressed as 10^6, we can substitute mega or M for 10^6.

For example: 88,000,000 Ω = 88 X 10^6 Ω = 88 M Ω.

(2) Kilo, abbreviated k, means thousand. Since 1,000 can be expressed as 10^3, we can substitute kilo or k for 10^3.

For example: 35,000 V = 35 X 10^3 V = 35 kV.

(3) Milli, abbreviated m, means one thousandth part of. Since .001 can be expressed as 10^{-3}, we can substitute milli or m for 10^{-3}.

For example: .002 A = 2 X 10^{-3} A = 2 mA.

(4) Micro, abbreviated μ , means one millionth part of. Since .000001 can be expressed as 10^{-6}, we can substitute micro or μ for 10^{-6}.

For example: .0000026 V = 2.6 X 10^{-6} V = 2.6 μV.

(5) Pico, abbreviated p, means one millionth of a millionth part of. Since .000000000001 can be expressed as 10^{-12}, we can substitute pico or p for 10^{-12}.

For example: .000000000155 A = 155 X 10^{-12} A = 155 pA.

No response required

FRAME
NO. 103 This chart shows the relationship between metric prefixes and their equivalent powers of 10. Study it for a moment.

Numerical Value	Prefix	Abbreviation	Power of 10
.000000000001	pico	p	10^{-12}
.000001	micro	μ	10^{-6}
.001	milli	m	10^{-3}
1	none	none	10^{0}
1,000	kilo	k	10^{3}
1,000,000	mega	M	10^{6}

FRAME
NO. 104 **PROBLEM**:

Cover the above chart with your hand and fill in the blocks below.

Numerical Value	Prefix	Abbreviation	Power of 10
.000000000001			
.000001			
.001			
1			
1,000			
1,000,000			

Correct any mistakes in this chart, then continue on the next page.

FRAME
NO. 105 Metric prefixes can be substituted for powers of 10 and vice versa:

10^6	=	mega or M
10^3	=	kilo or k
10^{-3}	=	milli or m
10^{-6}	=	micro or μ
10^{-12}	=	pico or p

FRAME
NO. 106 **PROBLEM**:

Cover the information above and fill in the blocks below.

Numerical Value	Prefix	Abbreviation	Power of 10
.000000000001			
.000001			
.001			
1			
1,000			
1,000,000			

Correct any mistakes in this chart, then continue on the next page.

FRAME
NO. 107

Numerical Value	Prefix	Abbreviation	Power of 10
.0000000000000001	Pico	p	10^{-12}
.00000001	micro	µ	10^{-6}
.001	milli	m	10^{-3}
1	none	none	10^{0}
1,000	kilo	K	10^{3}
1,000,000	mega	M	10^{6}

FRAME
NO. 108 Study the problem below, then continue.

220 mA = _______ µA

Solution: Substitute 10^{-3} for m and 10^{-6} for µ. Converting from 10^{-3} to 10^{-6} is a NEGATIVE 3 change in exponent, so the decimal point in 220 must move 3 places to the RIGHT.

NOTE: Remember, when converting a metric prefix to a smaller metric prefix, always move the decimal point to the RIGHT.

Thus: 220 milli amps becomes 220 X 10^{-3} amps when substituting 10^{-3} for milli and 220,000 X 10^{-6} amps when substituting 10^{-6} for micro. Your answer then becomes 220 milli amps = 220,000 micro amps.

FRAME
NO. 109 **PROBLEMS**:

Fill in the blank with the proper value.

3,000 µA = ___________________ mA

3,000 μA= ______________________ mA

FRAME
NO. 110 **ANSWER**: 3 mA

Solution:
3,000 μA = 3,000 X 10^{-6} A = 3 X 10^{-3} A = 3mA

Converting from 10^{-6} to 10^{-3} is a +3 change in exponent; the decimal point moves 3 places to the LEFT.

FRAME
NO 111 Study the problem below, then continue.

.002 mA = ______________________ uA

Solution: Substitute 10^{-3} for m and 10^{-6} for μ. You will then see that 10^{-3} to 10^{-6} is a NEGATIVE 3 change in exponent, so the decimal point in .002 moves 3 places to the RIGHT.

Thus: .002 mA = .002 X 10^{-3} A = 2 X 10^{-6} A = 2 μA

FRAME
NO. 112 **PROBLEM**:

Fill in the blank with the proper value.

110MΩ= __________________ Ω

FRAME
NO 113 **ANSWER**: 110,000,000 Ω

Solution:
110 M Ω = 110 X 10^{-6} Ω = 110,000,000 X 10^{0}
= 110,000,000 Ω

NOTE: 10^{6} to 10^{0} is a NEGATIVE 6 change in exponent.

FRAME
NO 114 **PROBLEM**:

Fill in the blocks.

Numerical Value	**Prefix**	**Abbreviation**	**Power of 10**
.000000000001			
.000001			
.001			
1			
1,000			
1,000,000			

FRAME
NO 115

Numerical Value	**Prefix**	**Abbreviation**	**Power of 10**
.000000000001	pico	P	10^{-12}
.00000	micro	μ	10^{-6}
.001	milli	m	10^{-3}
1	none	none	10^{0}
1,000	kilo	k	10^{3}
1,000,000	mega	M	10^{6}

FRAME
NO.116

We have seen that either METRIC PREFIXES or POWERS of 10 may be used to replace the zero digits in very large or small measurements.

For example: .000000000005 V = 5 X 10^{-12} V or 5 pV

33,000,000 Ω =33 X 10^{6} Ω or 33 mΩ

Usually, to solve a problem involving electrical measurements, all numbers with prefixes are converted to basic units times powers of 10. After the problem is solved, the answer may be expressed with a prefix if required or desired.

FRAME
NO. 117

PROBLEM:

Which of the following expressions are equivalent to .0000068 mA?

A. 6.8 pA
B. .0000000068 A
C. 6,800 pA
D. 6.8 X 10^{-12} A
E. 6.8 X 10^{-9} A

FRAME
NO. 118 **ANSWER**: B, C, and E are equivalent.

FRAME
NO. 119 Study the problem below, then continue.

$$\frac{100 \text{ mV}}{5\text{k } \Omega} = 20 \underline{\hspace{3em}} \text{ A}$$

Solution: Substitute equivalent powers of 10 for m and k; fill in the blank with the proper power of 10; then substitute a metric prefix for equivalent power of 10.

Thus: $$\frac{100 \text{ mV}}{5\text{k } \Omega} = \frac{100 \text{ X } 10^{-3} \text{ V}}{5 \text{ X } 10^{3} \; \Omega} = 20 \text{ X } 10^{-6} \text{ A} = 20 \; \mu\text{A}$$

NOTE: This is a practical electrical problem working with Ohm's law:

$$\frac{\text{volts (V)}}{\text{ohms } (\Omega)} = \text{amperes (A)}$$

FRAME
NO. 120 **PROBLEM**:

Fill in the blank with the proper metric prefix.

$$\frac{24 \text{ kV}}{2 \text{ mA}} = 12 \underline{\hspace{3em}} \; \Omega$$

FRAME
NO. 121 **ANSWER**: M

Solution: $\frac{24\ kV}{2\ mA} = \frac{24 \times 10^{3}\ V}{2 \times 10^{-3}\ A} = 12 \times 10^{6}\ \Omega = 12M\ \Omega$

FRAME
NO. 122 Study the problem below, then continue.

$3\ k\ \Omega \times 8\ \mu A = 24$ _______ V

Solution: Substitute powers of 10 for the metric prefixes; fill in the blank with the proper power of 10; then substitute. a metric prefix for the power of 10 in the blank.

Thus: $3\ k\ \Omega \times 8\ \mu A = 3 \times 10^{3}\ \Omega \times 8 \times 10^{-6}\ A = 24 \times 10^{-3}\ V$

$= 24\ mV$

FRAME
NO. 123 **PROBLEM**:

Fill in the blank with the proper metric prefix

$4M\ \Omega \times 4\ mA = 16$ _______ V

FRAME
NO. 124 **ANSWER**:

Solution:
4 M Ω X 4 mA = 4 X 10^6 Ω X 4 X 10^{-3} A = 16 X 10^3 V = 16 kV

FRAME
NO. 125 Study the problem below, then continue.

38 K Ω = _______ M Ω

Solution: Substitute 10^3 for k and 10^8 for M. You will then see that 10^3 to 10^6 is a POSITIVE 3 change in exponent. So the decimal point in 38 moves 3 places to the LEFT.

NOTE: Remember, when converting a metric prefix to a larger metric prefix, move the decimal point to the LEFT.

Thus: 38 kilohms becomes 38 X 10^3 ohms when substituting 10^3 for kilo and .038 X 10^8 ohms substituting 10^6 for mega. Your answer then becomes 38 kilohms = .038 megohms.

FRAME
NO. 126 **PROBLEM**:

Fill in the blank with the proper value.

15,000 Ω= _______ k Ω

FRAME
NO. 127 **ANSWER**: 15 k Ω

Solution: 15,000 Ω = 15,000 X 10^0 Ω = 15 X 10^3 Ω= 15 k Ω

NOTE: 10^0 to 10^3 is a POSITIVE 3 change in exponent.

FRAME
NO. 128 **PROBLEM**:

Fill in the blocks.

Numerical Value	Prefix	Abbreviation	Power of 10
.000000000001			
.000001			
.001			
1			
1,000			
1,000,000			

FRAME
NO. 129 **ANSWER**:

Numerical Value	Prefix	Abbreviation	Power of 10
.000000000001	pico	p	10^{-12}
.000001	micro	μ	10^{-6}
.001	milli	m	10^{-3}
1	none	none	10^{0}
1,000	kilo	k	10^{3}
1,000,000	mega	M	10^{6}

FRAME
NO. 130 Study the problem below, then continue.

$$\frac{30\ \text{kV}}{6\ \text{mA}} = 5\ \_\_\_\_\_\_\_\_\_\_\ \Omega$$

Solution: Substitute 10^3 for k and 10^{-3} for m; complete division of powers of 10 by inserting proper power of 10 in blank; substitute metric prefix in the blank.

Thus: $$\frac{30 \times 10^{3}\ \text{V}}{6 \times 10^{-3}\ \text{A}} = 5 \times 10^{6}\ \text{A} = 5\ \text{M}\ \Omega$$

FRAME
NO. 131 **PROBLEM**:

Fill in the blank with the proper metric prefix.

$3\ \text{M}\ \Omega \times 300\ \mu\ \text{A} = 900\ \_\_\_\_\_\_\_\_\_\_\_\_\ \text{V}$

FRAME
NO. 132 **ANSWER**: 900 V

Solution:
$3\ M\Omega \times 300\ \mu A = 3 \times 10^6\ \Omega \times 300 \times 10^{-6}\ \Omega = 900 \times 10^0\ V =$
$900 \times 1\ V = 900\ V$

NOTE: There is no metric prefix for 10^0 power; therefore, the numerical value of one (1) is substituted for 10^0 power and 900 X 1 is 900.

FRAME
NO. 133 **PROBLEM**:

Fill in the blanks with the proper values.

33 K Ω = _______ M Ω

2,400 Ω = _______ k Ω

4 M Ω = _______ Ω

FRAME
NO. 134 **ANSWER**: .033 M Ω

Solution: 33 k Ω = .033 M Ω — Converting k to M is a +3 exponent change.

ANSWER: 2.4 k Ω

Solution: 2,400 Ω = 2.4 k Ω — Converting basic units to k is a +3 exponent change.

ANSWER: 4,000,000 Ω

Solution: 4 M Ω = 4,000,000 Ω — Converting M to basic units is a -6 exponent change.

FRAME
NO. 135 **PROBLEM**:

Fill in the blanks with the proper metric prefixes.

3 k Ω X 9 μ A = 27 _______ V

$\frac{25\ \text{k V}}{5\ \text{mA}}$ = 5 ______ Ω

FRAME
NO 136 **ANSWER**: m

Solution:
$3\ k\Omega \times 9\ \mu A = 3 \times 10^3\ \Omega \times 9 \times 10^{-6}\ A = 27 \times 10^{-3} = 27\ mV$

ANSWER: M

Solution: $\dfrac{25\ kV}{5mA} = \dfrac{25 \times 10^3\ V}{5 \times 10^{-3}\ A} = 5 \times 10^6\ \Omega = 5\ M\Omega$

FRAME
NO. 137 **PROBLEM**:

Fill in the blanks with the proper values.

30 mV = _______________ V

350 pV = ______________ μ V

.04 mA = _____________ μ A

FRAME
NO. 138 **ANSWER**: .030 V
.000350 μ V
40 μ A

You have now completed this lesson. Review the objectives. If you do not understand the lesson, return to the frames which gave you trouble and repeat the examples given. Review this lesson completely before taking the examination on Page E-1.