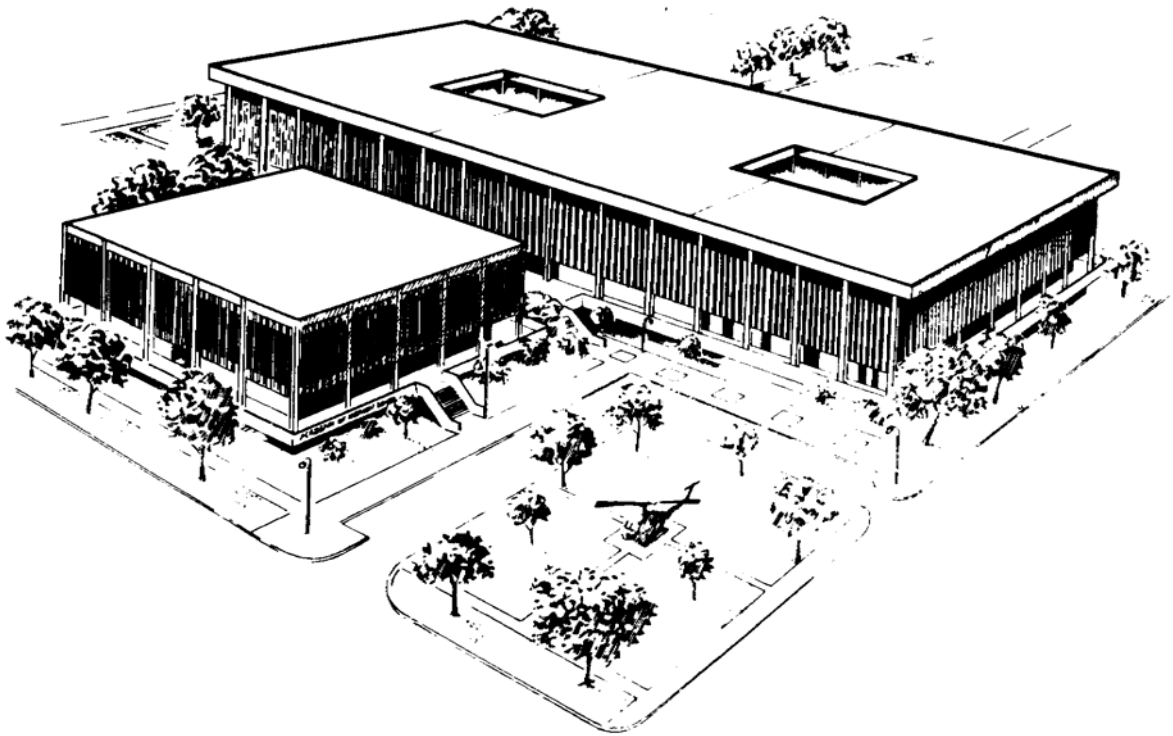

**U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL
FORT SAM HOUSTON, TEXAS 78234-6100**



BASIC ELECTRICAL CIRCUITS

SUBCOURSE MD0903

EDITION 200

DEVELOPMENT

This subcourse is approved for resident and correspondence course instruction. It reflects the current thought of the Academy of Health Sciences and conforms to printed Department of the Army doctrine as closely as currently possible. Development and progress render such doctrine continuously subject to change.

ADMINISTRATION

For comments or questions regarding enrollment, student records, or shipments, contact the Nonresident Instruction Section at DSN 471-5877, commercial (210) 221-5877, toll-free 1-800-344-2380; fax: 210-221-4012 or DSN 471-4012, e-mail accp@amedd.army.mil, or write to:

COMMANDER
AMEDDC&S
ATTN MCCS HSN
2105 11TH STREET SUITE 4192
FORT SAM HOUSTON TX 78234-5064

Approved students whose enrollments remain in good standing may apply to the Nonresident Instruction Section for subsequent courses by telephone, letter, or e-mail.

Be sure your social security number is on all correspondence sent to the Academy of Health Sciences.

CLARIFICATION OF TRAINING LITERATURE TERMINOLOGY

When used in this publication, words such as "he," "him," "his," and "men" are intended to include both the masculine and feminine genders, unless specifically stated otherwise or when obvious in context.

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**CORRESPONDENCE COURSE OF
THE US ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL**

**SUBCOURSE MDO903
BASIC ELECTRICAL CIRCUITS**

INTRODUCTION

This subcourse is designed to give you a basic knowledge of simple circuits that carry electricity from a power source to some kind of electrical equipment. With a knowledge of these fundamentals, you will be able to make better use of electrical equipment and to better understand future textual materials that mention electrical factors in the function of equipment.

Subcourse Components:

This subcourse consists of programmed text.

Lesson 1. Basic Electrical Circuits

Study Suggestions:

Here are some suggestions that may be helpful to you in completing this subcourse:

--Read and study each lesson carefully.

--Complete the subcourse lesson.

Credit Awarded:

To receive credit hours, you must be officially enrolled and complete an examination furnished by the Nonresident Instruction Section at Fort Sam Houston, Texas. Upon successful completion of the examination for this subcourse, you will be awarded 3 credit hours.

You can enroll by going to the web site <http://atrrs.army.mil> and enrolling under "Self Development" (School Code 555).

A listing of correspondence courses and subcourses available through the Nonresident Instruction Section is found in Chapter 4 of DA Pamphlet 350-59, Army Correspondence Course Program Catalog. The DA PAM is available at the following website: <http://www.usapa.army.mil/pdffiles/p350-59.pdf>.

SUBCOURSE MD0903

LESSON 1

Basic Electrical Circuits.

ASSIGNMENT

Frames 1 through 100.

OBJECTIVE

After completing the programmed text, you should be able to choose correct answers to questions about basic electrical circuits, current, resistance, amperes, volts, and equivalent.

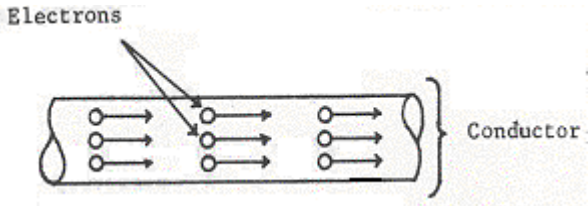
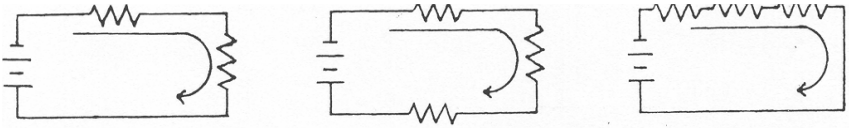
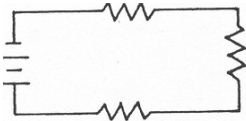
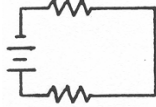
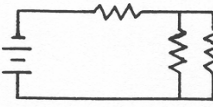
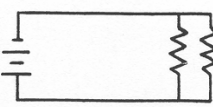
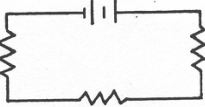
INSTRUCTIONS

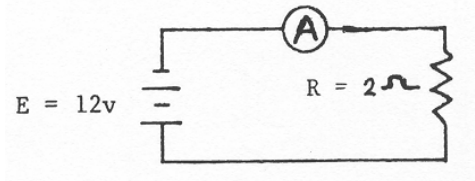
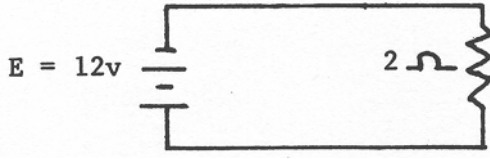
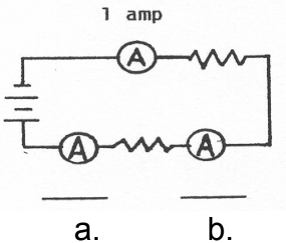
This text is set up differently from most subcourses. It is a workbook that utilizes programmed instruction. The numbered "frames" present information and/or a question about presented information. You should work through the frames in the order presented. Answer each question that is presented. To check your answers, go to the shaded box of the NEXT frame. For example, the solution to the question presented in Frame 2 is found in the shaded box of Frame 3.

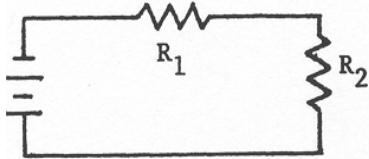
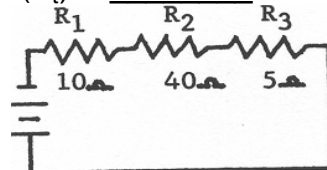
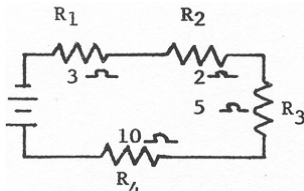
SUGGESTIONS

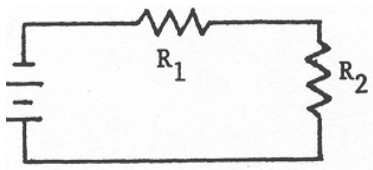
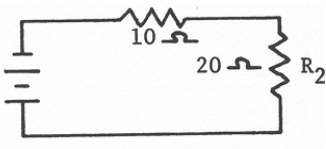
Read Subcourse MD0902, Basic Electricity, before taking this subcourse.

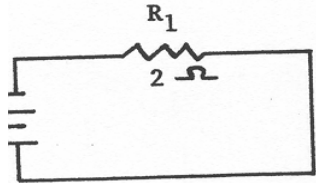
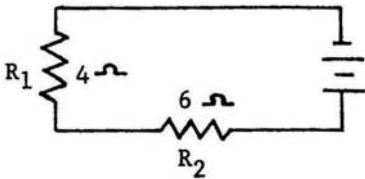
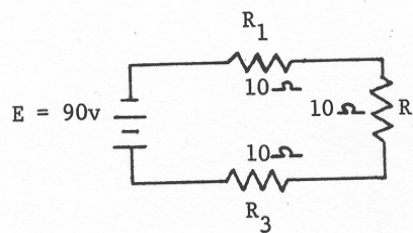
After going through the programmed text at a relatively slow pace, go back through it several times as rapidly as you can. This will not take long and will help you feel more knowledgeable as you study. The purpose of the programmed text is memorization as well as understanding.

FRAME 1 The diagram below will help you to recall that current is a flow of _____ through a conductor. 	
FRAME 2 Below are several series circuits. Study the carefully.  In a series circuit, there (is only one/are more than one) path for the current to flow.	Solution to Frame 1 electrons
FRAME 3  The above is a series circuit because _____.	Solution to Frame 2 is only one
FRAME 4 Label each circuit as either "Series" or "Not Series." a.  (Label here) b.  (Label here) c.  (Label here) d.  (Label here)	Solution to Frame 3 it has only one path for current to flow

FRAME 5 What would be the reading on the ammeter in the series circuit below? $I = \frac{E}{R} = \underline{\hspace{2cm}}$ 	Solution to Frame 4 a. Series b. Not Series c. Not Series d. Series
FRAME 6 No matter where you measure the current in the series circuit below, the current readings would all be the _____. 	Solution to Frame 5 $\frac{12v}{2 \Omega} = 6 \text{ amp}$
FRAME 7 In any part of a series circuit, the current is the _____ as long as the circuit is not changed.	Solution to Frame 6 same (6 amp)
FRAME 8 Write in the current reading of each ammeter connected in the series circuit below. 	Solution to Frame 7 same

FRAME 9 In any series circuit, the total resistance (R_t) is the sum (or total) of all the single resistances. In the series circuit below, R_t is the _____ of R_1 and R_2. 	Solution to Frame 8 a. 1 amp b. 1.amp
FRAME 10 a. The total resistance (R_t) in the series circuit below is $10\ \Omega + 40\ \Omega +$ _____ Ω. b. Total resistance (R_t) is _____ ohms. 	Solution to Frame 9 sum (or total)
FRAME 11 In the series circuit below  $R_1 =$ _____ $R_2 =$ _____ $R_3 =$ _____ $R_4 =$ _____ The total resistance (R_t) is _____.	Solution to Frame 10 a. 5 b. 55

FRAME 12 So far, you have learned that in series circuits: - There is (<u>only one/more than one</u>) path for the current to flow. - Current has (<u>the same value/different values</u>) everywhere in the circuit. - To get R_t (total resistance), we (add/subtract/multiply) all the individual resistances.	Solution to Frame 11 $R_1 = 3 \Omega$ $R_2 = 2 \Omega$ $R_3 = 5 \Omega$ $R_4 = 10 \Omega$ $(R_t) = 20 \Omega$
FRAME 13 To find I_t (current in any series circuit), you must use R_t in the formula $I_t = \frac{E_t}{R_t}$  To find I_t in the circuit above, you must use _____ in the formula _____.	Solution to Frame 12 - only one - the same value - add
FRAME 14 To find I in the series circuit below, you must use (<u>10/20/30/200</u>) Ω in the formula $I_t = \frac{E_t}{R_t}$ 	Solution to Frame 13 R_t $I_t = \frac{E_t}{R_t}$

FRAME 15 In a series circuit with only one resistor, R_1 and R_t must be the same. In the series circuit below, there is only one resistor. This means the R_1 and R_t (<u>are/are not</u>) the same. They are both equal to _____. 	Solution to Frame 14 30
FRAME 16 To find the current in the circuit below, you would substitute the number (<u>4/6/10/24</u>) for R_t in the formula $I_t = \frac{E_t}{R_t}$. 	Solution to Frame 15 are 2 Ω
FRAME 17 In the circuit below, $E_t = \underline{\hspace{2cm}}$. $R_t = \underline{\hspace{2cm}}$. Find the current $I_t = \underline{\hspace{2cm}}$. 	Solution to Frame 16 10

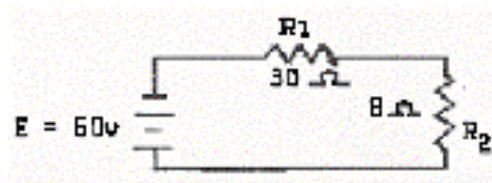
FRAME 18

If you calculated current (I) in the circuit below and used this formula:

a. $I_t = \frac{E_t}{R_1}$, your answer would be (right/wrong).

b. $I_t = \frac{E_t}{R_2}$, your answer would be (right/wrong).

c. $I_t = \frac{E_t}{R_t}$, your answer would be (right/wrong).

**Solution to Frame 17**

90v

30Ω

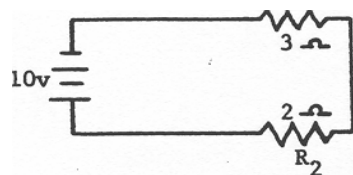
3 amp

$$I_t = \frac{E_t}{R_t} = \frac{90v}{30\Omega} = 3 \text{ amp}$$

FRAME 19

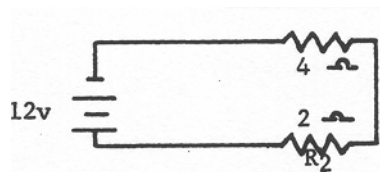
In the circuit below, find I.

Example: :



$$I_t = \frac{E_t}{R_t} = \frac{10 \text{ v}}{(2+3) \Omega} = \frac{10v}{5\Omega} = 2 \text{ amps}$$

You do this one:



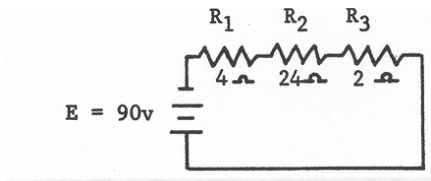
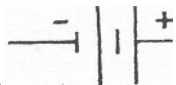
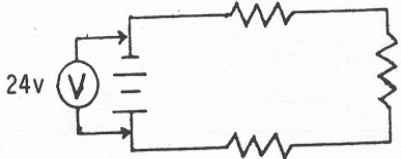
= _____

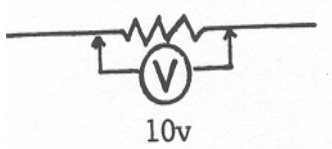
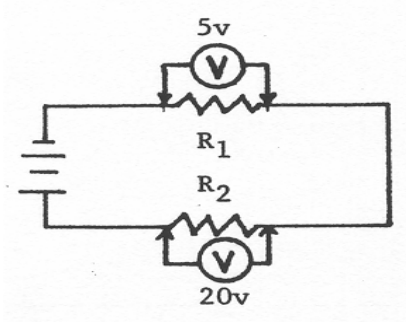
Solution to Frame 18

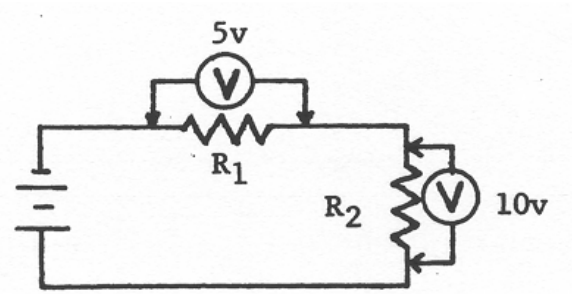
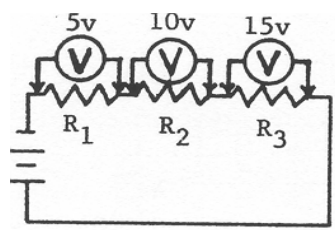
a. wrong

b. wrong

c. right

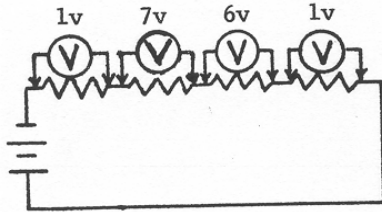
FRAME 20 In the circuit below, $I_t =$ _____. 	Solution to Frame 19 $I_t = \frac{E_t}{R_t} = \frac{12 \text{ v}}{6 \Omega} = 2 \text{ amps}$
FRAME 21 So far, you have learned that in series circuits: - There is/are (<u>only one/more than one</u>) path for the current to flow. - Current has the (<u>same/different</u>) value everywhere in the circuit. - To get R_t, we (<u>sum/subtract</u>) all individual resistances. - To find I_t, you must use (<u>R_1/R_t</u>) _____ in the formula $I_t = \frac{E_t}{R_t}$.	Solution to Frame 20 3 amp $I_t = \frac{E_t}{R_t}$ $= \frac{90 \text{ v}}{30 \Omega}$ $= 3 \text{ amp}$
FRAME 22 The voltage applied by a battery is called the applied voltage (E_a).  This battery will apply a voltage called the _____.	Solution to Frame 21 - only one - same - sum R_t
FRAME 23 In the circuit below, the E_a (applied voltage) is _____ volts. 	Solution to Frame 22 applied voltage (E_a)

FRAME 24 To move a wagon uphill, you must apply a force. To move electrons through a resistor, a battery must also apply _____.	Solution to Frame 23 24
FRAME 25 When you move a wagon uphill, force is used up. When electrons are pushed through a resistance, electromotive force (EMF) is also _____.	Solution to Frame 24 a force (or a voltage)
FRAME 26 When EMF is used up, the voltage drops. Across any resistance, EMF is used up and the voltage _____.	Solution to Frame 25 used up
FRAME 27 The drop in voltage is called voltage drop.  Across the resistor above, we have a 10v _____.	Solution to Frame 26 drops
FRAME 28 In the diagram below, the voltage drop across R_1 is _____ and across R_2, it is _____. 	Solution to Frame 27 voltage drop

FRAME 29 You have learned that the symbol for voltage is E. For voltage drop across R_1, you will use the symbol E_1. For voltage drop across R_2, you will use the symbol E_2. For voltage drop across R_3, you will use the symbol ____.	Solution to Frame 28 (R_1) 5v (R_2) 20v
FRAME 30 Total voltage drop (E_t) is the sum of all individual voltage drops. In the circuit below, E_t is the _____ of E_1 and E_2. $E_t = \underline{\hspace{2cm}}$. 	Solution to Frame 29 E_3
FRAME 31 E_t (total voltage drop) in this circuit is _____ volts. 	Solution to Frame 30 total (or sum) 15v

FRAME 32

E_t in the circuit below is _____.



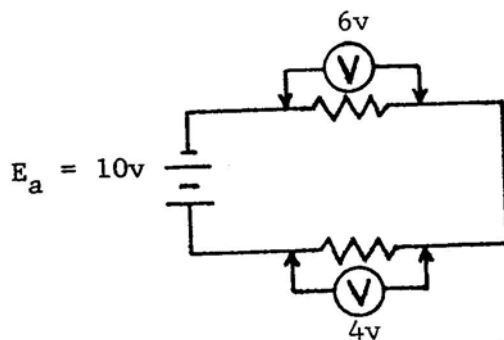
Solution to Frame 31

30

FRAME 33

E_t (total voltage drop) in the circuit below is _____.

E_t (applied voltage) is also _____.

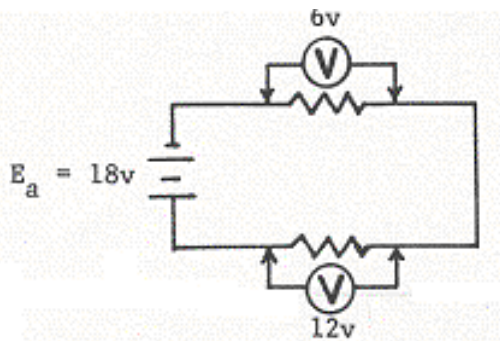


Solution to Frame 32

15v

FRAME 34

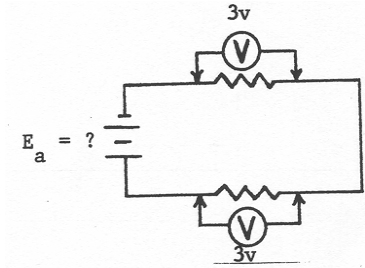
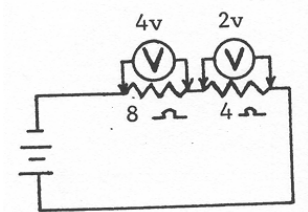
In the series circuit below, the E_a (applied voltage) is _____, and the E_t (total voltage) is _____. E_t and E_a are (the same/different) in any series circuit.



Solution to Frame 33

10v

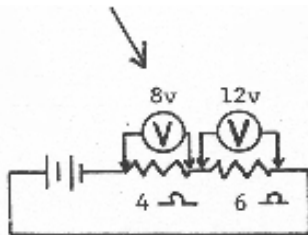
10v

FRAME 35 E_t in the circuit below is _____; E_a is _____. 	Solution to Frame 34 18v 18v the same
FRAME 36 If $E_t = 24v$, then $E_a =$ _____ If $E_a = 6v$ then $E_t =$ _____ If any series circuit, E_t and E_a are _____.	Solution to Frame 35 6v 6v
FRAME 37 One way to find I (current) in a series circuit is to use E_t in the formula $I_t = \frac{E_t}{R_t}$  To find I_t in the circuit above, use _____ in the formula _____.	Solution to Frame 36 24v 6v the same (equal)

FRAME 38

Find I in the circuit below.

Example:

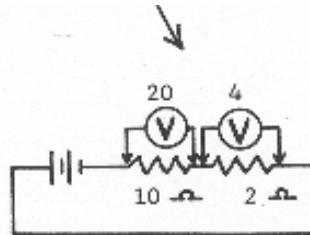


$$I_t = \frac{E_t}{R_t} =$$

$$= \frac{20v}{10\Omega}$$

$$I_t = 2 \text{ amps}$$

You work this problem.



$$I_t = \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

$$I_t = \underline{\hspace{2cm}}$$

Solution to Frame 37

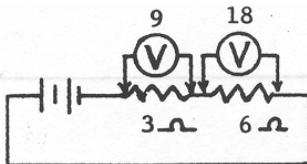
$$E_t$$

$$I_t = \frac{E_t}{R_t}$$

FRAME 39

Find I in the circuit below.

Example:

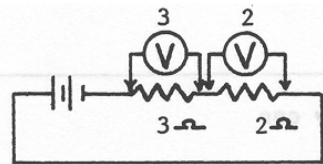


$$I_t = \frac{E_t}{R_t} =$$

$$= \frac{27v}{9\Omega}$$

$$= 3 \text{ amps}$$

You do this:



$$I_t = \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

$$I_t = \underline{\hspace{2cm}}$$

Solution to Frame 38

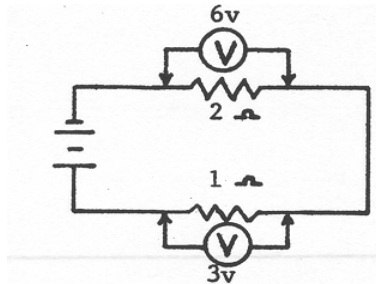
$$\frac{E_t}{R_t}$$

$$\frac{24v}{12\Omega}$$

$$2 \text{ amp}$$

FRAME 40

I (current) in the series circuit below is _____.



Solution to Frame 39

$$I_t = \frac{E_t}{R_t}$$

$$= \frac{5v}{5\Omega}$$

$$= 1 \text{ amp}$$

FRAME 41

You just learned that to find I in a series circuit, you use the formula: $I_t = \frac{E_t}{R_t}$.

Since $E_a = E_t$, you (may/may not) also use the formula

$$I_t = \frac{E_a}{R_t}$$

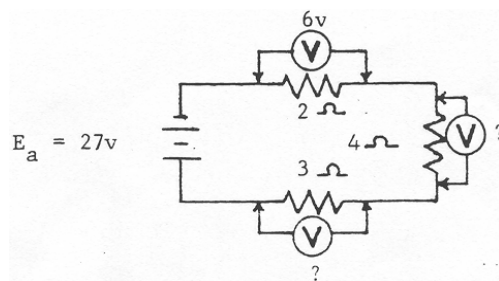
Solution to Frame 40

$$3 \text{ amp}$$

$$\frac{9v}{3\Omega} = 3 \text{ amp}$$

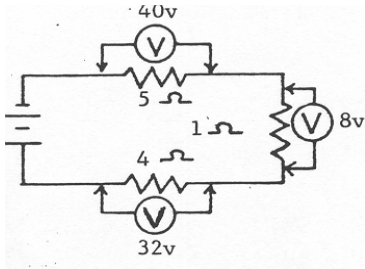
FRAME 42

In the circuit below I = _____.



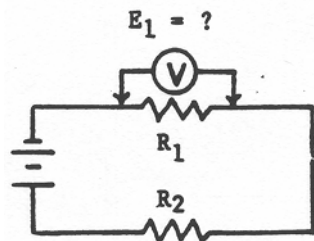
Solution to Frame 41

may

FRAME 43 Find I in the circuit below: I = _____ 	Solution to Frame 42 3 amp $\frac{E_a}{R_t} = \frac{27v}{9\Omega} = 3 \text{ amp}$ drop at side resistor = 12 v. drop at bottom resistor = 9 v
FRAME 44 So far you have learned that in a series circuit: - There is/are (<u>only one/more than one</u>) path for the current to flow. - I (current) has (<u>the same/a different</u>) value(s) everywhere in the circuit - To get R_t, you (<u>sum/subtract</u>) the individual voltage resistances. - To get E_t, you (<u>sum/subtract</u>) the individual voltage drops. E_t and E_a (<u>are/are not</u>) the same. - To find I, you (<u>must/must not</u>) use R_t. - To find I, you (<u>must/must not</u>) use either E_t or E_a.	Solution to Frame 43 8 amp $I_t = \frac{E_t}{R_t} = \frac{80v}{10\Omega} = 8 \text{ amp}$
FRAME 45 The statement “The greater the resistance, the greater the voltage drop” does not tell you how to calculate the exact voltage drop. However, Ohm’s law does allow you to _____.	Solution to Frame 44 - only one - the same - sum - sum - are - must - must

FRAME 46

To calculate E (voltage drop across R_1) exactly, you use the formula $E_1 = I_1 \times R_1$:



To calculate E_1 in the circuit above, you use the formula _____.

Solution to Frame 45

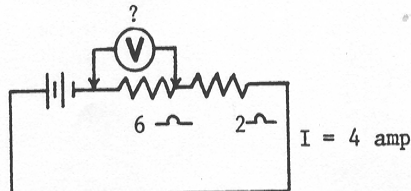
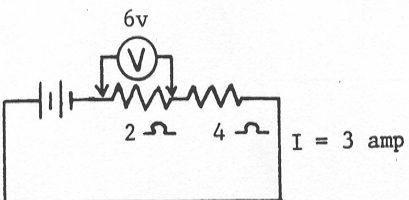
calculate the exact voltage drop

FRAME 47

Find E_1 in the circuits below:

Example:

You do this one



$$E_1 = I \times R_1$$

$$= 3 \text{ amp} \times 2\Omega$$

$$= 6 \text{ v}$$

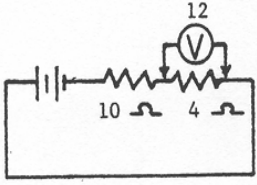
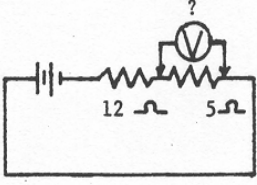
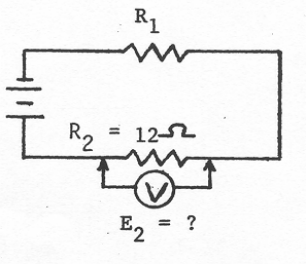
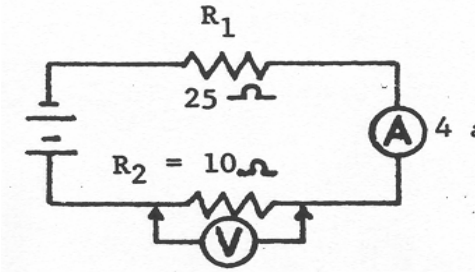
$$E_1 = \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

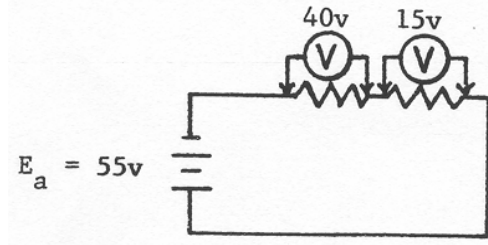
Solution to Frame 46

$$E_1 = I_1 \times R_1$$

FRAME 48 Example: $E_2 = I \times R_2$ $= 3 \text{ amp} \times 4\Omega$ $= 12\text{v}$  $I = 3 \text{ amp}$ You do this one: $E_2 = \underline{\hspace{2cm}}$ $= \underline{\hspace{2cm}}$ $= \underline{\hspace{2cm}}$  $I = 3 \text{ amp}$	Solution to Frame 47 $E_1 = I_1 \times R_1$ $= 4 \text{ amp} \times 6\Omega$ $= 24\text{v}$
FRAME 49 In the circuit below $I = 2 \text{ amp}$. Find E_2 (voltage drop across R_2). $E_2 = \underline{\hspace{2cm}}$. 	Solution to Frame 48 $E_2 = I \times R_2$ $= 3 \text{ amp} \times 5\Omega$ $= 15\text{v}$
FRAME 50 Compute E_2 in the circuit below: $E_2 = \underline{\hspace{2cm}}$. 	Solution to Frame 49 24v $E_2 = I \times R_2$ $= 2 \text{ amp} \times 12\Omega$ $= 24\text{v}$

FRAME 51

To check the total voltage drops, you can sum the individual voltage drops to get E_t . This should equal E_a .



The voltage drops calculated above (do/do not) check.

Solution to Frame 50

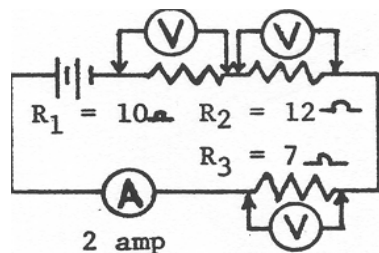
$$\begin{aligned} E_2 &= I \times R_2 \\ &= 4 \text{ amp} \times 10\Omega \\ &= 40\text{v} \end{aligned}$$

FRAME 52

In the circuit below, find E_1 , E_2 , E_3 .

$$E_1 = \underline{\hspace{2cm}} \quad E_2 = \underline{\hspace{2cm}}$$

$$E_3 = \underline{\hspace{2cm}} \quad E_t = \underline{\hspace{2cm}}$$

**Solution to Frame 51**

do

FRAME 53

Sometimes you will not be told the value of I (current). Therefore, before you can compute E_1 , or E_2 , or E_3 , you must find the value of $\underline{\hspace{2cm}}$ to use in the formulas:

$$E_1 = I_1 \times R_2$$

$$E_2 = \underline{\hspace{2cm}} \times R_2$$

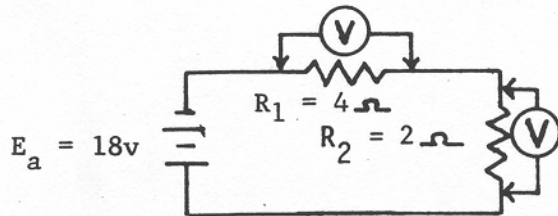
$$E_3 = \underline{\hspace{2cm}}$$

Solution to Frame 52

$$\begin{aligned} E_1 &= 20\text{v} \\ E_2 &= 24\text{v} \\ E_3 &= 14\text{v} \\ E_t &= 58\text{v} \end{aligned}$$

FRAME 54

To find E_1 in the circuit below, you must first find _____. You find I now. $I =$ _____ amp.

**Solution to Frame 53**

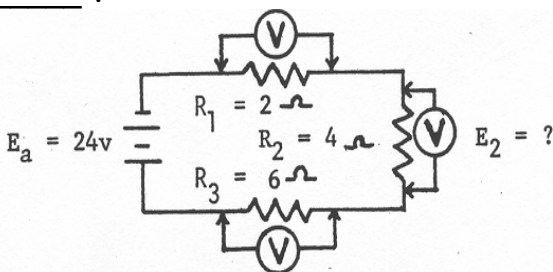
I
 I_2
 $I_3 \times R_3$

FRAME 55

In the circuit below, find I and then E_2 .

$I =$ _____ amp

$E_2 =$ _____ v

**Solution to Frame 54**

Total resistance

$$\frac{E_a}{R_t} = \frac{18v}{6\Omega} = 3 \text{ amp}$$

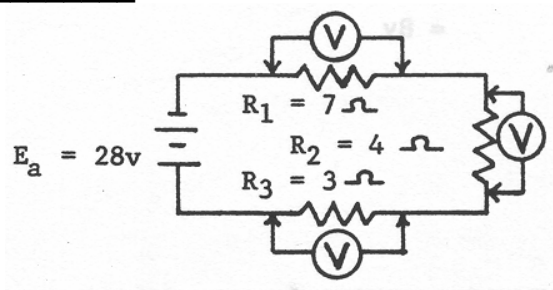
FRAME 56

In the circuit below, find I , E_1 , E_2 , and E_3 . $I =$ _____

$E_1 =$ _____

$E_2 =$ _____

$E_3 =$ _____

**Solution to Frame 55**

$$I = \frac{E_a}{R_t} = \frac{24v}{12\Omega} = 2 \text{ amp}$$

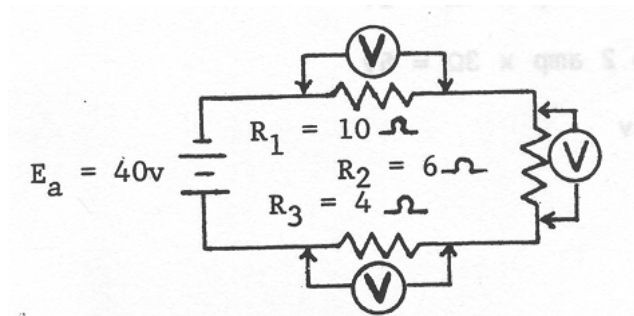
$$E_2 = I \times R_2$$

$$= 2 \text{ amp} \times 4\Omega$$

$$= 8v$$

FRAME 57

In the circuit below, find: $E_1 = \underline{\hspace{1cm}}$; $E_2 = \underline{\hspace{1cm}}$; $E_3 = \underline{\hspace{1cm}}$.
 Check: $\underline{\hspace{2cm}}$.

**Solution to Frame 56**

2 amps ($R_t = 7 + 4 + 3 = 14\Omega$)

$$I = \frac{E_a}{R_t} = \frac{28}{14} = 2 \text{ amps}$$

$$E_1 = I \times R_1 = 2 \text{ amp} \times 7\Omega = 14\text{v}$$

$$E_2 = I \times R_2 = 2 \text{ amp} \times 4\Omega = 8\text{v}$$

$$E_3 = I \times R_3 = 2 \text{ amp} \times 3\Omega = 6\text{v}$$

Yes, $28\text{v} = 28\text{v}$

FRAME 58

To summarize what you have learned about series circuits, complete the statements below:

- There is/are (only one/more than one) path for current to flow.
- I (current) has (the same/a different) value(s) everywhere in the circuit.
- To get R_t , you (sum/subtract) the individual resistances.
- To get E_t , you (sum/subtract) the individual voltage drops.
- E_t and E_a (are/are not) the same.
- To find I , you (must/must not) use R_t .
- To find I , you (must/must not) use E_t or E_a .
- To find E_1 , use the formula $\underline{\hspace{2cm}}$
- To find E_3 , use the formula $\underline{\hspace{2cm}}$.

Solution to Frame 57

$$E_1 = 20\text{v}$$

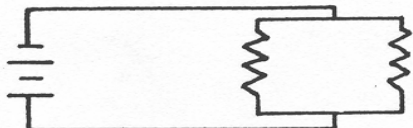
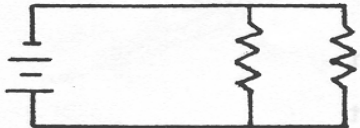
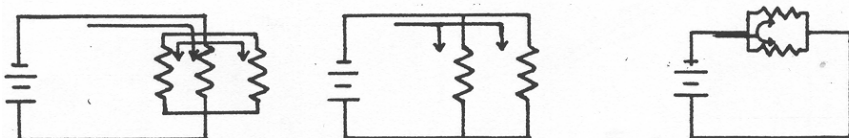
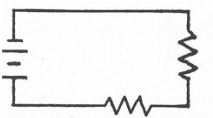
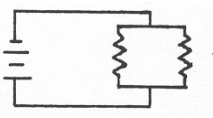
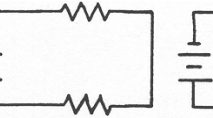
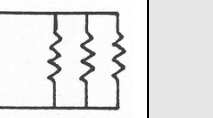
$$E_2 = 12\text{v}$$

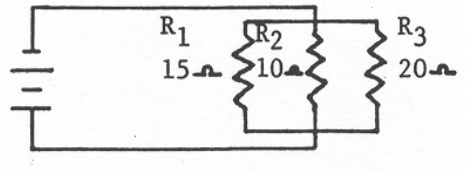
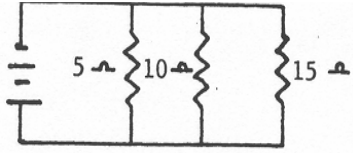
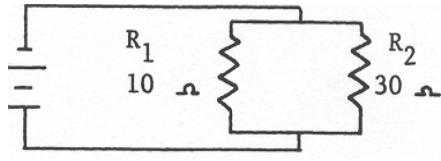
$$E_3 = 8\text{v}$$

Check:

$$E_a = E_t$$

$$40\text{v} = 40\text{v}$$

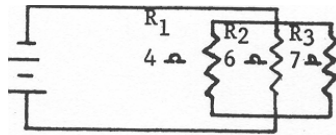
FRAME 59 This is one way of placing resistors in parallel.  This is another way of placing resistors in parallel.  Both of the above circuits are _____ circuits.	Solution to Frame 58 - only one - the same - sum - sum - are - must - must $E_1 = I \times R_1$ $E_3 = I \times R_3$
FRAME 60 These are all parallel circuits. The arrows show the paths of current flow.  A parallel circuit has (<u>only one/more than one</u>) path for current flow.	Solution to Frame 59 parallel
FRAME 61 The circuit below is broken at point A. Current still flows because parallel circuit have (<u>only one/more than one</u>) path for current flow. 	Solution to Frame 60 more than one
FRAME 62 Label each circuit as either “parallel” or “series.” a.  (Label) b.  (Label) c.  (Label) d.  (Label)	Solution to Frame 61 more than one

FRAME 63 Now let us look at resistance. In the parallel circuit below, resistance 1 (R_1) is 15Ω; R_2 is _____Ω; and R_3 is _____Ω. 	Solution to Frame 62 a. Series b. Parallel c. Series d. Parallel
FRAME 64 In any parallel circuit, R_t (total resistance) is less than the smallest resistance. In the circuit below, R_t is less than _____Ω. 	Solution to Frame 63 10 20
FRAME 65 R_t will be less than 10Ω in the circuit below. R_t is always (<u>more/less</u>) than the smallest resistance. 	Solution to Frame 64 5
FRAME 66 So far you have learned that: a. A parallel circuit has (<u>only one/more than one</u>) path for current flow. b. R_t is (<u>more/less</u>) than the (<u>largest/smallest</u>) resistance in a parallel circuit.	Solution to Frame 65 less

FRAME 67

To determine the value of R_t in a parallel circuit, use the formula:

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}, \text{ etc.}}$$



In the circuit above, you use the formula $R_t =$ _____.

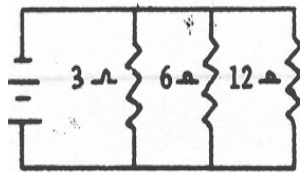
Solution to Frame 66

- a. more than one
- b. less; smallest

FRAME 68

Find R_t

Example



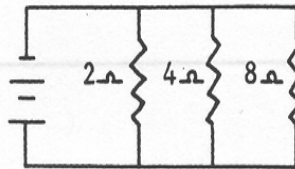
$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$= \frac{1}{\frac{1}{3} + \frac{1}{6} + \frac{1}{12}}$$

$$= \frac{1}{\frac{4}{12} + \frac{2}{12} + \frac{1}{12}} = \frac{1}{\frac{7}{12}} = \frac{12}{7}$$

$$= 1.714 \Omega$$

Problem



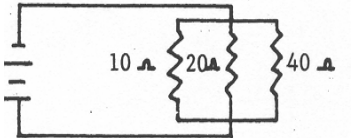
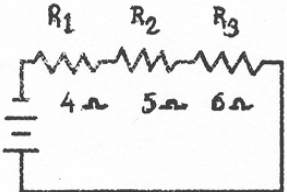
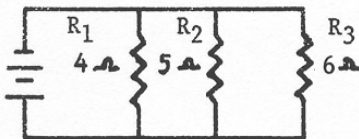
$$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

$$= \underline{\hspace{2cm}}$$

$$= \underline{\hspace{2cm}}$$

Solution to Frame 67

$$R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

FRAME 69 a. In the parallel circuit below, R_t equals _____. b. R_t (is/is not) less than the smallest resistor. 	Solution to Frame 68 $R_t = \frac{1}{\frac{1}{2} + \frac{1}{4} + \frac{1}{8}}$ $\frac{1}{\frac{4}{8} + \frac{2}{8} + \frac{1}{8}} = \frac{1}{\frac{7}{8}} = \frac{8}{7}$ $= 1.14\Omega$
FRAME 70 So far you have learned that: a. A parallel circuit has (<u>only one/more than one</u>) path for current to flow. b. To find R_t, you use the formula _____. c. You can check on any R_t you compute because the R_t in a parallel circuit must be (<u>more/less</u>) than the (<u>largest/smallest</u>) resistance.	Solution to Frame 69 a. $R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$ $R_t = \frac{1}{\frac{1}{10} + \frac{1}{20} + \frac{1}{40}}$ $\frac{1}{\frac{4}{40} + \frac{2}{40} + \frac{1}{40}} = \frac{1}{\frac{7}{40}} = \frac{40}{7}$ $R_t = 5.71\Omega$ b. is
FRAME 71 To help prevent confusion between finding R_t in series circuits and finding R_t in parallel circuits, answer the questions below:   a. To find R_t in the SERIES CIRCUIT above, use this formula: b. To find R_t in the PARALLEL CIRCUIT above, use this formula:	Solution to Frame 70 a. more than one b. $R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$ c. less, smallest

FRAME 72

A series circuit that has the same E_a and the same R_t as a parallel circuit is called an equivalent circuit. The series circuit below is a/an _____ circuit because _____.



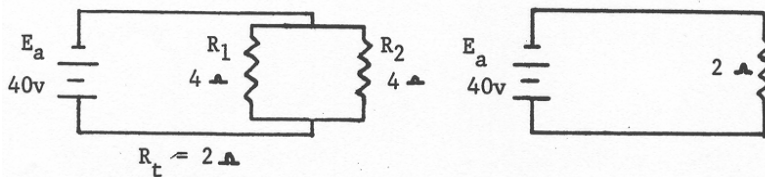
Solution to Frame

a. $R_t = R_1 + R_2 + R_3$

b. $R_t = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$

FRAME 73

The series circuit below is an equivalent circuit because both circuits (do/do not) have the same E_a and both circuits (do/do not) have the same R_t .



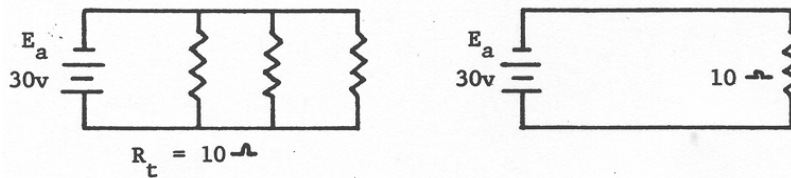
Solution to Frame 72

equivalent

it has the same E_a and R_t as the parallel circuit

FRAME 74

The series circuit below is a/an _____ circuit because _____.



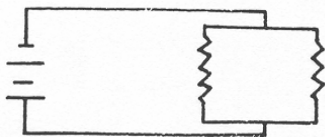
Solution to Frame 73

do

do

FRAME 75

To draw an equivalent circuit for the parallel circuit below, you would first draw a (series/parallel) circuit with one resistor. Draw the series circuit in the space below.



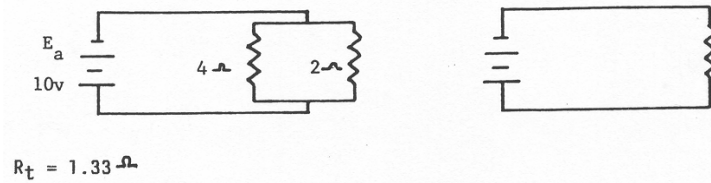
Solution to Frame 74

equivalent

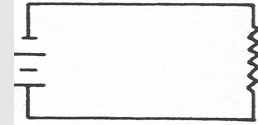
both circuits have the same E_a and the same R_t

FRAME 76

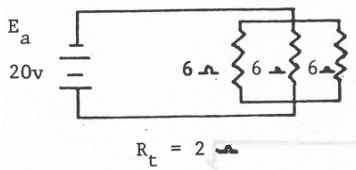
The equivalent circuit must have the same E_a and R_t . Write in the correct E_a and R_t on the series circuit below.

**Solution to Frame 75**

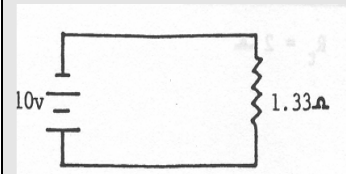
series

**FRAME 77**

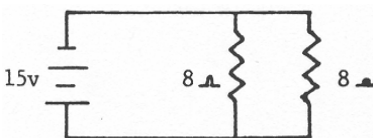
Draw a equivalent circuit for the parallel circuit below.



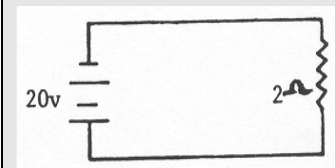
(Draw equivalent circuit here.)

Solution to Frame 76**FRAME 78**

Sometimes, of course, R_t is not given. Before you can draw the equivalent circuit, you must find _____. Find R_t and then draw the equivalent circuit.

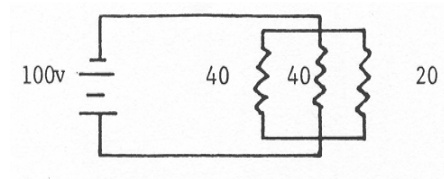


Draw equivalent circuit here.

Solution to Frame 77

FRAME 79

For this parallel circuit, draw an equivalent circuit.

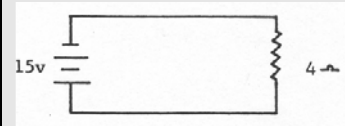


_____ Draw equivalent circuit here.

Solution to Frame 78

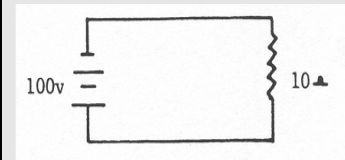
R_t

$$R_t = \frac{1}{\frac{1}{8} + \frac{1}{8}} = 4\Omega$$

**FRAME 80**

So far you have learned that:

- A parallel circuit has _____ for current to flow.
- R_t for a parallel circuit = _____.
- You can check on any R_t you compute because the R_t in a parallel circuit must be (more/less) than the (largest/smallest) resistor.
- An equivalent circuit is a (series/parallel) circuit with the same _____ and _____ as a parallel circuit.

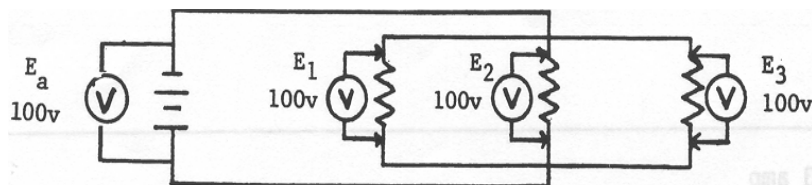
Solution to Frame 79

$$\frac{1}{\frac{1}{40} + \frac{1}{40} + \frac{2}{40}} =$$

$$\frac{1}{\frac{4}{40}} = \frac{40}{4} = 10$$

FRAME 81

In the parallel circuit below, E_a (applied voltage), E_1 (voltage drop across R_1), E_2 (voltage drop across R_2), and E_3 (voltage drop across R_3) are (the same/different).

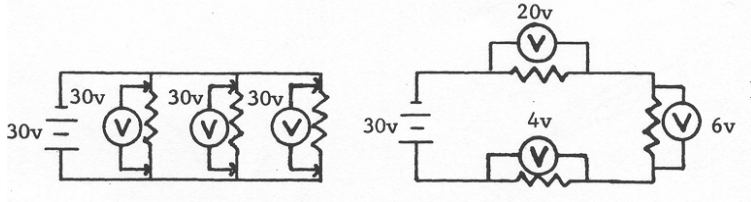
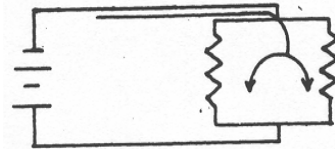
**Solution to Frame 80**

- more than one path

$$b. \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

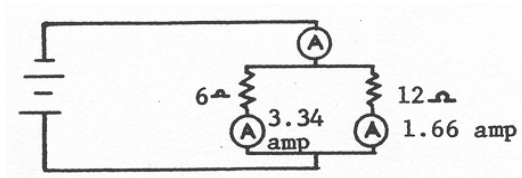
- less; smallest

- series; E_a ; R_t

FRAME 82 In parallel circuit, the voltage drop across each branch is always (<u>the same/different</u>).	Solution to Frame 81 the same
FRAME 83 In a parallel circuit, the voltage drop across each resistor (regardless of size) is the same. In a series circuit, the voltage drops are (<u>the same/different</u>) according to the size of the resistor. 	Solution to Frame 82 the same
FRAME 84 Now that you know what happens to resistance and voltage in a parallel circuit, let us look at current. The diagram below shows that in a parallel circuit, the current splits and flows through (<u>only one/each</u>) resistor. 	Solution to Frame 83 different
FRAME 85 Because the current splits up and flows through each resistor, it is important that you know how to compute the current flowing through _____.	Solution to Frame 84 each
FRAME 86 You have learned that the symbol for current is I. The symbol for the current flowing through R_1 is I_1. The symbol for the current flowing through R_2 is I_2 The symbol for the current flowing through R_3 is _____.	Solution to Frame 86 each resistor

FRAME 87

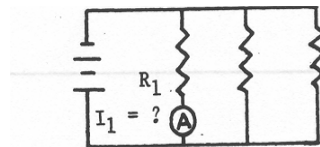
The diagram below shows that when the current splits, more current will flow through the (larger/smaller) resistor.

**Solution to Frame 86**

I_3

FRAME 88

To accurately measure I_1 (current flow through R_1), you use the formula $I_1 = \frac{E_a}{R_1}$, since $E_1 = E_a$.



To measure I_1 in the circuit above, you use the formula _____.

Solution to Frame 87

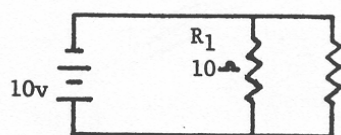
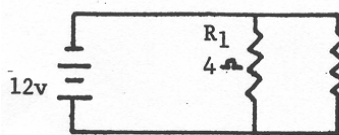
smaller

FRAME 89

Find I_1 in the circuits below.

Example

You do this one.



$$I_1 = \frac{E_a}{R_1}$$

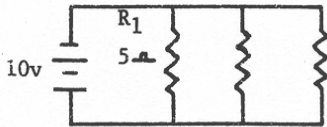
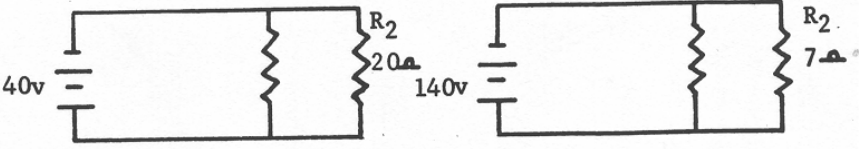
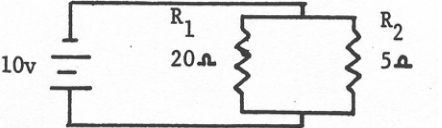
$$= \frac{12v}{4\Omega}$$

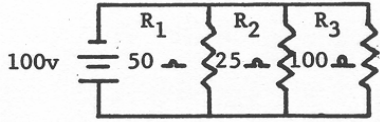
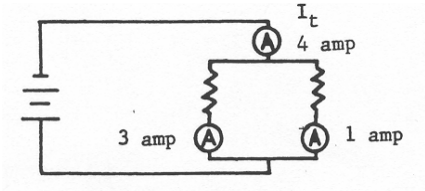
$$= 3 \text{ amp}$$

$$I_1 =$$

Solution to Frame 88

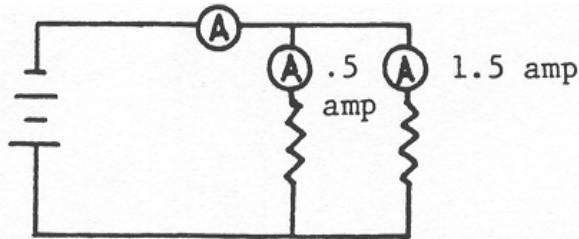
$$I_1 = \frac{E_a}{R_1}$$

FRAME 90 In the circuit below, I_1 equals _____. 	Solution to Frame 89 $I_1 = \frac{E_a}{R_1}$ $= \frac{10v}{10\Omega}$ $= 1 \text{ amp}$
FRAME 91 Find I_2 in the circuit below: Example You do this one.  $I = \frac{E_a}{R_2}$ $= \frac{40v}{20\Omega}$ $= 2 \text{ amp}$	Solution to Frame 90 $I_1 = \frac{E_a}{R_1}$ $= \frac{10v}{5\Omega}$ $= 2 \text{ amp}$
FRAME 92 In the circuit below, I_1 equals _____, I_2 equals _____. 	Solution to Frame 91 $I_1 = \frac{E_a}{R_2}$ $= \frac{140v}{7\Omega}$ $= 20 \text{ amp}$

FRAME 93 In the circuit below, find I_1, I_2, and I_3. $I_1 = \underline{\hspace{2cm}}$, $I_2 = \underline{\hspace{2cm}}$, $I_3 = \underline{\hspace{2cm}}$. 	Solution to Frame 92 $I_1 = \frac{E_a}{R_1} = \quad I_2 = \frac{E_a}{R_2}$ $\frac{10v}{20\Omega} = \quad \frac{10v}{5\Omega} =$ 0.5 amp 2 amp
FRAME 94 To find I_1, you use the formula $I_1 = \frac{E_a}{R_1}$ To find I_2, you use the formula $I_2 = \frac{E_a}{R_2}$ To find I_3, you use the formula $I_3 = \frac{E_a}{R_3}$ To find I_4, you would use the formula $I_4 = \underline{\hspace{2cm}}$ To find I_5, you would use the formula $I_5 = \underline{\hspace{2cm}}$	Solution to Frame 93 $I_1 = \frac{E_a}{R_1} = \frac{100v}{50\Omega} = 2 \text{ amp}$ $I_2 = \frac{E_a}{R_2} = \frac{100v}{25\Omega} = 4 \text{ amp}$ $I_3 = \frac{E_a}{R_3} = \frac{100v}{100\Omega} = 1 \text{ amp}$
FRAME 95 The diagram below shows that I_t (total current) flowing into the branches is the (<u>sum/difference</u>) of the current in each branch. 	Solution to Frame 94 $\frac{E_a}{R_4}$ $\frac{E_a}{R_5}$

FRAME 96

In the circuit below, I_t is _____ amp.

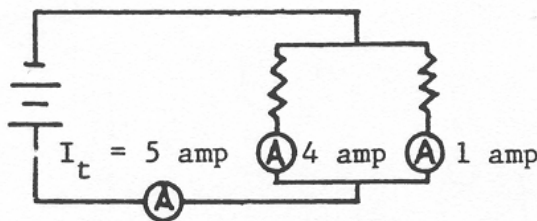


Solution to Frame 95

sum

FRAME 97

The diagram below shows that I_t flowing out of the branches is the (sum/difference) of the current in each branch.

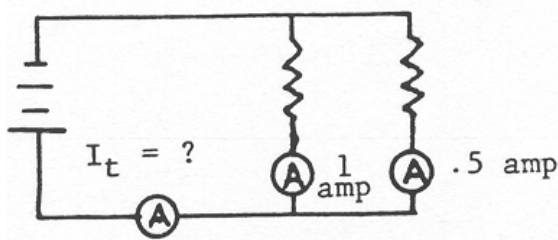


Solution to Frame 96

2 amp (0.5 + 1.5)

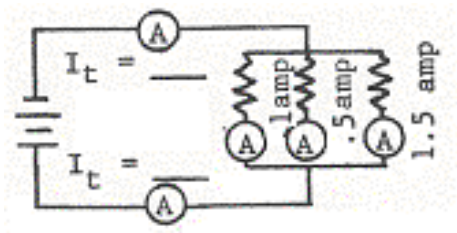
FRAME 98

In the circuit below, I_t is the (sum/difference) of I_1 and I_2 .
Thus $I_t =$ _____.



Solution to Frame 97

sum

FRAME 99 Fill in the value of I_t measured at the two ammeters below: 	Solution to Frame 98 sum 1.5 amp (1 + 0.5)
FRAME 100 In a series circuit, current has only one path to follow; therefore, it has the same value everywhere in the circuit. In a parallel circuit, the current (<u>splits/does not split</u>). The current in a parallel circuit (<u>does/does not</u>) have the same value everywhere.	Solution to Frame 99 3 amp (1 + 0.5 + 1.5) 3 amp (1 + 0.5 + 1.5)
FRAME 101 Congratulations. You have now completed this programmed instruction booklet. It is recommended that you review the lesson material before taking the examination.	Solution to Frame 100 splits does not

End of Lesson 1