SPH3U UNIVERSITY PHYSICS

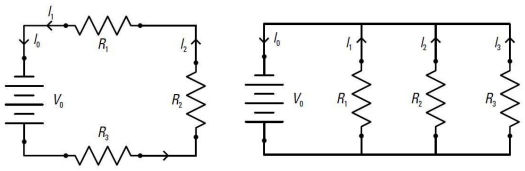
ELECTRICITY & MAGNETISM

- Circuit Analysis (P.531-535)

Analyzing Circuits

Before we can analyze a simple series or parallel electric circuit containing resistances we need to answer two basic questions:

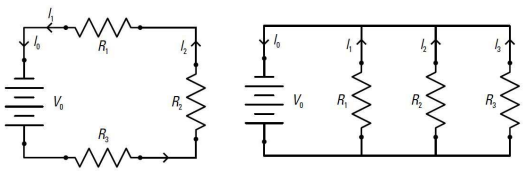
1. *What happens when we add resistances in series? in parallel?*



Analyzing Circuits

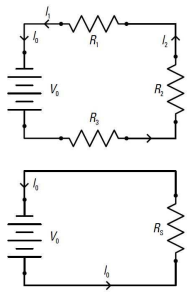
Before we can analyze a simple series or parallel electric circuit containing resistances we need to answer two basic questions:

2. *Can we reduce multiple resistances to a single resistance? And if so, what is the equivalent resistance?*



Resistance in Series

Consider an electric circuit with three resistors connected in series. Kirchhoff's laws and Ohm's law can be used to reduce the three resistors to a single resistor with an equivalent value of R_S.



$\therefore \quad V_0 = V_1 + V_2 + V_3$

$\therefore \quad I_0 R_S = I_1 R_1 + I_2 R_2 + I_3 R_3$

$\therefore \quad I_0 = I_1 = I_2 = I_3$

$\therefore \quad I_0 R_S = I_0 R_1 + I_0 R_2 + I_0 R_3$

or $\boldsymbol{R_S = R_1 + R_2 + R_3}$

Resistance in Series

PRACTICE

1. What is the equivalent resistor in a series circuit containing a 16 Ω light bulb, a 27 Ω heater, and a 12 Ω motor?

   $R_S = 55\ \Omega$

Resistance in Series

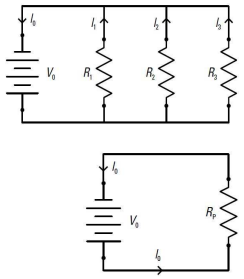
PRACTICE

2. Two identical unknown bulbs are connected in series with a 48 Ω and a 64 Ω heater to produce an equivalent resistance of 150 Ω. What is the resistance of each bulb?

   $R_1 = R_2 = 19\ \Omega$

Resistance in Parallel

We can use the same approach to find the equivalent resistance R_P of three resistors connected in parallel.



$\therefore \quad I_0 = I_1 + I_2 + I_3$

$\therefore \quad V_0/R_P = V_1/R_1 + V_2/R_2 + V_3/R_3$

$\therefore \quad V_0 = V_1 = V_2 = V_3$

$\therefore \quad V_0/R_P = V_0/R_1 + V_0/R_2 + V_0/R_3$

or $\mathbf{1/R_P = 1/R_1 + 1/R_2 + 1/R_3}$

Resistance in Parallel

PRACTICE

3. Find the equivalent resistor when a 4 Ω bulb and a 8 Ω bulb are connected in parallel.

   $R_P = 2.7\ \Omega$

Resistance in Parallel

PRACTICE

4. An unknown resistor is connected in parallel with a 30 Ω and a 40 Ω resistor to produce an equivalent resistance of 15 Ω. What is the resistance of the unknown resistor?

   $R_3 = 120\ \Omega$

Equivalent Resistance in Series & Parallel Circuits

EQUIVALENT RESISTANCE

- in series

$$R_{series} = R_1 + R_2 + \ldots$$

- in parallel

$$\frac{1}{R_{parallel}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

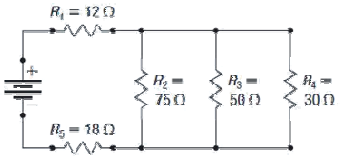
NOTE!

- When resistance is added in series, the total resistance increases.
- When resistance is added in parallel, the total resistance decreases.

Equivalent Resistance in Mixed Circuits

NOTE!

Mixed circuits, like the one shown, contain both series and parallel connections. In order to analyze a mixed circuit, you divide the circuit into sections that are connected in parallel or series and analyze them accordingly.

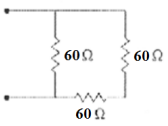


Equivalent Resistance in Mixed Circuits

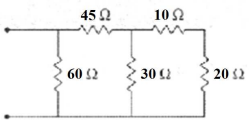
PRACTICE

5. Calculate the equivalent resistance (R_{total}) for each circuit shown.

(a)



(b)

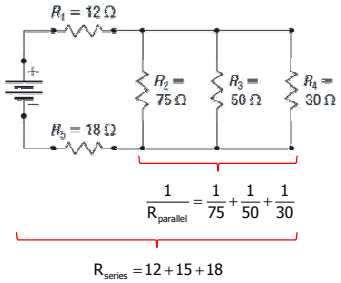


(a) R_{total} = 40 Ω
(b) R_{total} = 30 Ω

Equivalent Resistance in Mixed Circuits

PRACTICE

6. Calculate the equivalent resistance (R_{total}) for the circuit shown.



$R_{parallel}$ = 15 Ω

R_{total} = R_{series} = 45 Ω

$$\frac{1}{R_{parallel}} = \frac{1}{75} + \frac{1}{50} + \frac{1}{30}$$

$$R_{series} = 12 + 15 + 18$$

Analyzing Circuits

With what you've learned about electricity you should now be able to do a complete analysis of any simple series, parallel or mixed electric circuit containing resistances. However, because so many different electric circuits are possible, there is no standard approach to analyzing a circuit. The steps to take in each case will depend upon the information you have about the circuit, and what you want to find out.

Analyzing Circuits

HINTS!

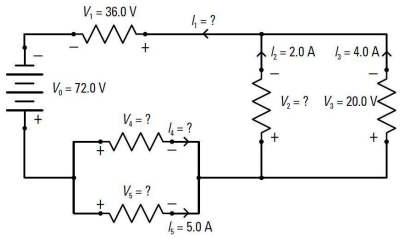
1. *In most cases you can use KVL and KCL to find the values of two of **V**, **I**, or **R**. You can then use V=IR to calculate the missing value.*
2. *In some cases you must first reduce the circuit to a single equivalent resistance to find I_{SOURCE} .*

Analyzing Mixed Circuits

PRACTICE

6. Find the missing values for the circuit given.

$I_1 = 6.0$ A
$V_2 = 20.0$ V
$I_4 = 1.0$ A
$V_4 = 16.0$ V
$V_5 = 16.0$ V

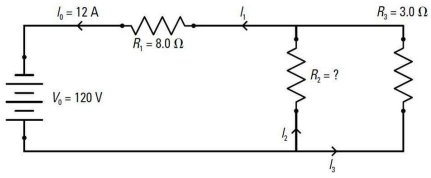


Analyzing Mixed Circuits

PRACTICE

7. Find V_1, V_2, V_3, I_1, I_2, I_3 and R_2 for the circuit given.

$I_1 = 12$ A
$V_1 = 96$ V
$V_3 = 24$ V
$I_3 = 8.0$ A
$V_2 = 24$ V
$I_2 = 4.0$ A
$R_2 = 6.0\ \Omega$



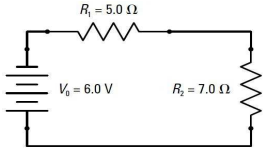
Analyzing Mixed Circuits

PRACTICE

8. Complete each circuit given by finding the unknown quantities indicated.

(a) I_0, I_1, I_2, V_1, V_2

(a) $I_0 = I_1 = I_2 = 0.5$ A (KCL)
$V_1 = 2.5$ V
$V_3 = 3.5$ V

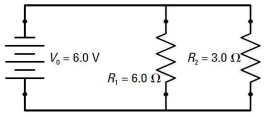


Analyzing Mixed Circuits

PRACTICE

8. Complete each circuit given by finding the unknown quantities indicated.

(b) V_1, V_2, I_0, I_1, I_2



(b) $V_1 = V_2 = 6.0$ V (KVL)
$I_1 = 1$ A
$I_2 = 2$ A
$I_0 = 3$ A

Activity: Analyzing Circuits (Inv.11.8.1/P.536)

INSTRUCTIONS

A. Follow procedure steps 1-16.
B. For parts A and B use the following:
   - one source (V_{source} = 10 V)
   - two resistors (R_1 = 5 Ω & R_2 = 20 Ω)
C. For part C use the following:
   - one source (V_{source} = 10 V)
   - four resistors (R_1 = 10 Ω, R_2 = 5 Ω, R_3 = 15 Ω, & R_4 = 20 Ω)
   - mixed circuit diagram (Q.1(c)/P.535)

NOTE!

You will be using an electronic circuit construction kit. Do a Google search for **phet dc kit**.

Activity: Analyzing Circuits (Inv.11.8.1/P.536)

QUESTIONS

P.537 Q.(b)-(h)
P.535 Q.2-4/P.535 ☜ be neat and be sure to show your work!