Ohm's Law

Ohm's law states that there is a simple relationship between **voltage**, **current** and **resistance**. Current and voltage are both proportionate to each other and inversely proportional to resistance. This is expressed by the equations:

V = IR	where **V** is electrical pressure in **Volts**,
I = V/R	**I** is current in **Amperes**, and
R = V/I	**R** is resistance in **Ohms**

For example, a circuit consisting one resistor of 300 Ohms is powered by a 6 volt battery. Using Ohm's law we can calculate the amount of current that will flow through the circuit.

I = V/R
I = 6/300 = 2/100 = 1/50 = .02 Amperes = 20 **milliamps**

Series and Parallel Circuits

Electronic circuits can be either **series** or **parallel**. A series circuit is one in which there is only one path for current to flow. In a parallel circuit, there are at least 2 paths for current flow, much like branches of a river. Most circuits are made up of several branches of series and parallel circuits.

Kirchoff's Laws of Series Circuits

1. The total resistance of the circuit is equal to the sum of the resistance of each individual component.
2. The current is the same at any point in the circuit.
3. The total voltage is equal to the sum of all of the voltage drops within the circuit.

Kirchoff's Laws of Parallel Circuits

1. The total resistance is less than the smallest resistance in the circuit and is equal to the inverse of the sum of the inverse of each resistance (Rt= 1/(1/r1+1/r2+1/rn).
2. The total current is the sum of the current in each branch.
3. The voltage is equal across each branch.

The Power Law

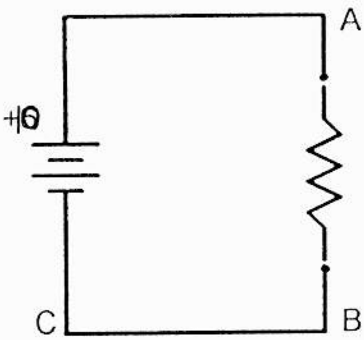
The Power Law describes the relationship between voltage, current and power. Power is a measure of the capacity to do work and is measured in **Watts.**

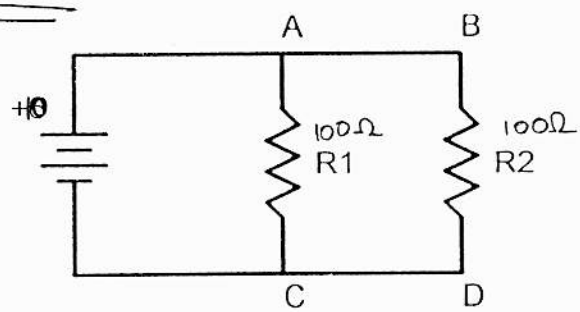
P = IV	where **V** is electrical pressure in **Volts**,
I = V/P	**I** is current in **Amperes**, and
V = P/I	**P** is power in **Watts**

Experiment

Construct the following circuits. Calculate voltage, current and resistance at each labelled branch. Then measure the values at the same points. Do your calculated results match your measured results? When you construct the circuits, pick the resistors randomly. Redo some of the experiments after changing the power supply voltage from 6 to 9 volts.

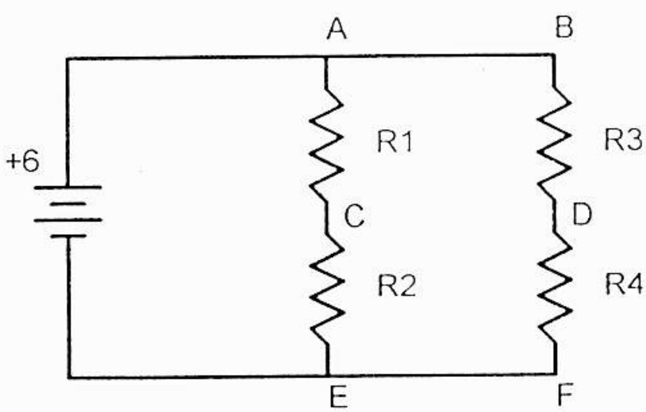
10V / 100Ω

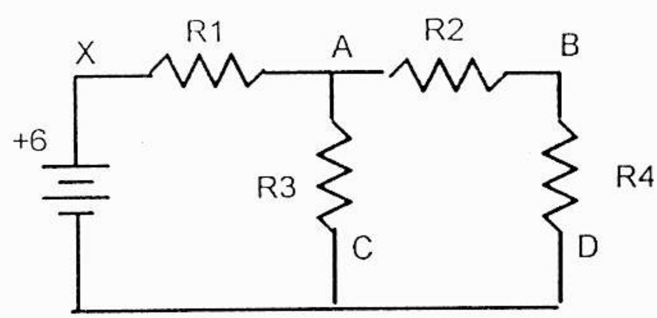




	calculated	measured
Va	= 1amps	
Vbc	= 0	
Ia	= .1amps	
R1	= 100 Ω	
Vab	= 10V	
Ib	= .1amps	

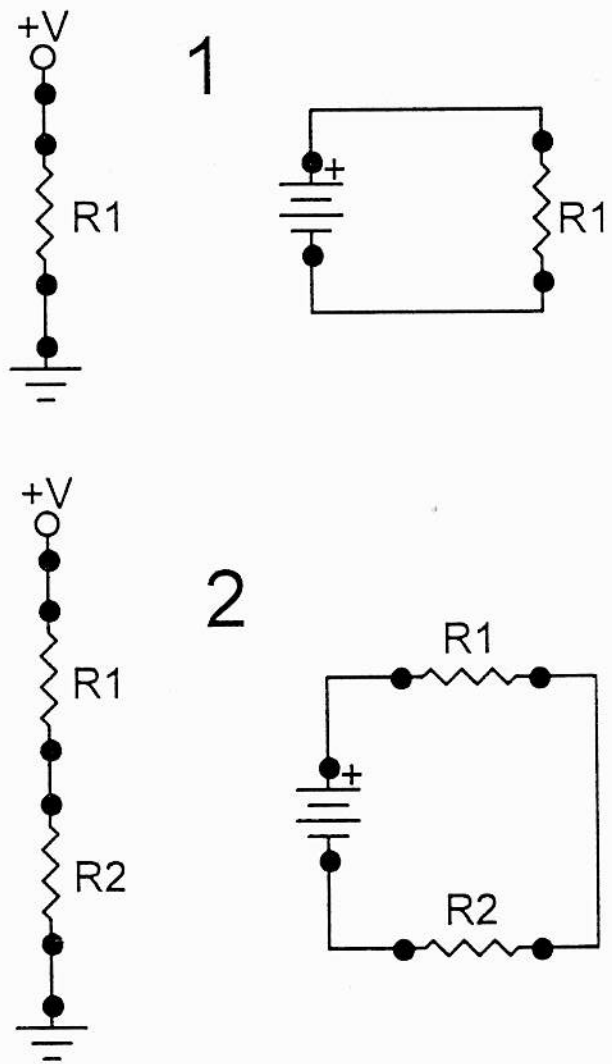
	calculated	measured
R1	= .1 amps	
R2	= .1 amps	
Req	= Rt (Rtotal) = 50Ω	
Vac	=	
Vbd	=	
Ia	=	
Ib	=	
Ic	=	



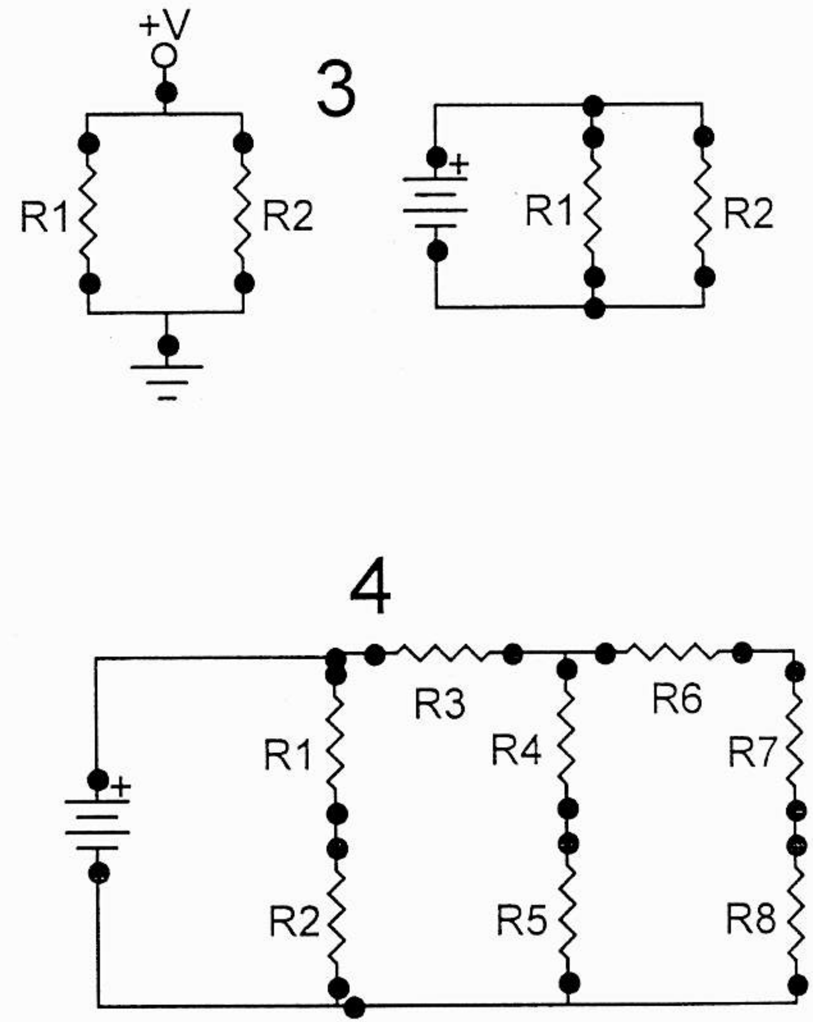


	calculated	measured
Req	=	
Ic	=	
Id	=	
Ie	=	
If	=	
Vac	=	
Vce	=	
Vbd	=	
Vdf	=	

	calculated	measured
Req	=	
Iar3	=	
Iar2	=	
Ib	=	
Id	=	
Vab	=	
Vbd	=	
Vac	=	
Vxa	=	



Series Circuits



Parallel Circuits

100 ohms / 10 volts

Quantities and units

Physical quantities are such things as **mass***, **force*** and **current***, which are used in the physical sciences. They all have to be measured in some way and each therefore has its own **unit**. These are chosen by international agreement and are called **International system** or **SI units** (abbreviated from the French Système International). All quantities are classified as either **basic quantities** or **derived quantities**.

- **Basic quantities.** A set of quantities from which all other quantities (see **derived quantities**) can be defined (see table, right). Each basic quantity has its **basic SI unit**, in terms of which any other SI unit can be defined.

Basic quantity	Symbol	Basic SI unit	Abbreviation
Mass	m	kilogram	kg
Length	l	metre	m
Time	t	second	s
Current	I	ampere	A
Temperature	T	kelvin	K
Quantity of substance	-	mole	mol
Luminous intensity	-	candela	cd

Basic SI units

- **Kilogram (kg).** The SI unit of mass. It is equal to the mass of an international prototype metal cylinder kept at Sevres, near Paris.
- **Metre (m).** The SI unit of length. It is equal to the length of 1 650 763.73 **wavelengths*** of a certain type of radiation emitted by the krypton-86 atom.
- **Second (s).** The SI unit of time. It is equal to the duration of 9 192 631 770 **periods*** of a certain type of radiation emitted by the caesium-133 atom.
- **Ampere (A).** The SI unit of electric current (see also page 60). It is equal to the size of a current flowing through parallel, infinitely long, straight wires in a vacuum that produces a force between the wires of 2×10^{-7} N every metre.
- **Kelvin (K).** The SI unit of temperature. It is equal to 1/273.16 of the temperature of the **triple point** of water (the point at which ice, water and steam can all exist at the same time) on the **absolute temperature scale***.
- **Mole (mol).** The SI unit of the quantity of a substance (note that this is different from mass because it is the number of particles of a substance). It is equal to the amount of substance which contains 6.02×10^{23} (this is **Avagadro's number**) particles (e.g. atoms or molecules).
- **Candela (cd).** The SI unit of intensity of light. It is equal to the strength of light from 1/600 000 square metres of a **black body*** at the temperature of freezing platinum and at a pressure of 101 325 N m^{-2}.

Prefixes

A given SI unit may sometimes be too large or small for convenience, e.g. the metre is too large for measuring the thickness of a piece of paper. Standard fractions and multiples of the SI units are therefore used and are written by placing a prefix before the unit (see tables below and right). For example, the millimetre (mm) is equal to one thousandth of a metre.

Standard fractions and multiples (those involving powers of 10^3, e.g. 10^3, 10^6, 10^{-3}).

Fraction	Prefix	Symbol
10^{-3}	milli-	m
10^{-6}	micro-	μ
10^{-9}	nano-	n

Multiple	Prefix	Symbol
10^3	kilo-	k
10^6	mega-	M
10^9	giga-	G

Other fractions and multiples in use

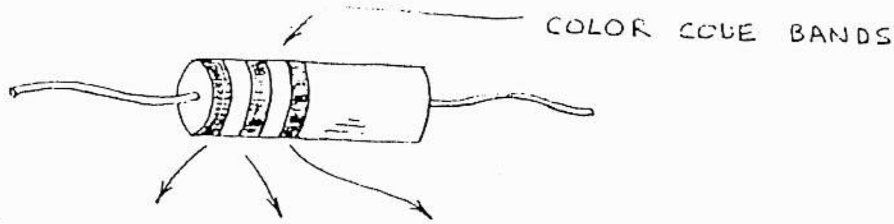
Fraction or multiple	Prefix	Symbol
10^2	hecto-	h
10^1	deca-	dc
10^{-1}	deci-	d
10^{-2}	centi-	c

* Absolute temperature scale, 27; Black body, 29 (Leslie's cube); Current, 60; Force, 6; Mass, 12; Period, 16; Wavelength, 34.

- **Derived quantities.** Quantities other than **basic quantities** which are defined in terms o[f] in terms of other derived quantities. The derived quantities have **derived SI units** which [a]defined in terms of the **basic SI units** or other derived units. They are worked out from th[e] equation for the quantity and are sometimes given special names.

Derived quantity	Symbol	Defining equation	Derived SI unit	Name of unit	Abbreviation
Velocity	v	$v = \frac{\text{distance}}{\text{time}}$	m s^{-1}	-	-
Acceleration	a	$a = \frac{\text{velocity}}{\text{time}}$	m s^{-2}	-	-
Force	F	F = mass × acceleration	kg m s^{-2}	newton	N
Work	W	W = force × distance	N m	joule	J
Energy	E	Capacity to do work	J	-	-
Power	P	$P = \frac{\text{work done}}{\text{time}}$	J s^{-1}	watt	W
Area	A	Depends on shape (see page 101)	m^2	-	-
Volume	V	Depends on shape (see page 101)	m^3	-	-
Density	ρ	$\rho = \frac{\text{mass}}{\text{volume}}$	kg m^{-3}	-	-
Pressure	p	$p = \frac{\text{force}}{\text{area}}$	N m^{-2}	pascal	Pa
Period	T	Time for one cycle	s	-	-
Frequency	f	Number of cycles per second	s^{-1}	hertz	Hz
Impulse	-	Impulse = force × time	N s	-	-
Momentum	-	Momentum = mass × velocity	kg m s^{-1}	-	-
Electric charge	Q	Q = current × time	A s	coulomb	C
Potential difference	V	$V = \frac{\text{energy transferred}}{\text{charge}}$	J C^{-1}	volt	V

☐ RESISTOR COLOR CODE — SEE THOSE COLOR CODE BANDS ON THE RESISTOR PICTORIAL? IN REAL LIFE THEY'RE KIND OF PRETTY. BUT THEY HAVE A FAR MORE IMPORTANT PURPOSE: THEY INDICATE THE RESISTANCE OF THE RESISTOR THEY DECORATE. HERE'S HOW:



COLOR	1	2	3 (MULTIPLIER)
BLACK	0	0	1
BROWN	1	1	10
RED	2	2	100
ORANGE	3	3	1,000
YELLOW	4	4	10,000
GREEN	5	5	100,000
BLUE	6	6	1,000,000
VIOLET	7	7	10,000,000
GRAY	8	8	100,000,000
WHITE	9	9	(NONE)

NOTE: SOMETIMES THERE'S A FOURTH BAND. IT INDICATES THE TOLERANCE* OF THE RESISTOR:

GOLD = ± 5 %
SILVER = ± 10 %
NONE = ± 20 %

* OR ACCURACY

LOOKS COMPLICATED THE FIRST TIME... BUT YOU'LL QUICKLY LEARN HOW TO USE IT. FOR EXAMPLE, WHAT'S THE RESISTANCE OF A RESISTOR COLOR CODED YELLOW, VIOLET AND RED? YELLOW IS THE FIRST COLOR SO THE FIRST NUMBER IS 4. VIOLET IS THE SECOND COLOR SO THE SECOND NUMBER IS 7. SINCE THE THIRD COLOR IS RED, THE MULTIPLIER IS 100. THEREFORE, THE RESISTANCE IS 47 × 100 OR 4700 OHMS. NO FOURTH COLOR BAND MEANS THE ACTUAL RESISTANCE IS 4700 ± 20 %. 20 % OF 4700 IS 940. THEREFORE, THE ACTUAL VALUE IS BETWEEN 3760 AND 5640 OHMS.

☐ SUBSTITUTING RESISTORS — WHAT IF YOU NEED A 6700-OHM RESISTOR BUT CAN ONLY FIND A 6800-OHM UNIT? YOU CAN ALMOST ALWAYS USE ANY VALUE WITHIN 10 OR 20% OF THE REQUIRED VALUE SO GO AHEAD AND USE IT. IF A PARTICULAR CIRCUIT REQUIRES MORE ACCURACY IT WILL TELL YOU. OF COURSE YOU CAN BUILD UP CUSTOM RESISTANCES BY CONNECTING TWO OR MORE RESISTORS IN SERIES OR IN PARALLEL. MORE ABOUT THAT LATER.