Class 12: Circuits Analysis

AP Physics

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Olympiads School

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Notice: Tim Will Be Away Next Week

Tim will be away to do a concert in Ottawa next Saturday (February 17). There will be a supply teacher for next week. Please be kind to him! Tim will return to Olympiads on Sunday, February 18,, and will resume teaching this class on the 24th (class 14).

Files for You to Download

Download from the school website:

1. `12-Cicuits.pdf`—This presentation. If you want to print on paper, I recommend printing 4 pages per side.
2. `13-Homework.pdf`—Homework assignment for this class and next class. The file will be ready when Class 13 slides are posted.

Please download/print the PDF file before each class. There is no point copying notes that are already printed out for you. Instead, take notes on things I say that aren't necessarily on the slides.

Resistors

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Ohm's Law

Power Dissipated by a Resistor

We know (from Physics 11) that power is the rate at which work W is done, and we also know from electrostatics, the change in electric potential energy ΔE_q (i.e. the work done!) is proportional to the amount of charge q and the voltage V. Now we can get a very simple expression for power. through a resistor:

$$P = \frac{dW}{dt} = \frac{d(qV)}{dt} = \left(\frac{dq}{dt}\right) = \boxed{IV}$$

Quantity	**Symbol**	**SI Unit**
Power through a resistor	P	W (watt)
Current through a resistor	I	A (ampere)
Voltage across the resistor	V	V (volt)

Other Equations for Power

When we combine Ohm's Law ($V = IR$) with power equation, we get two additional expressions for power through a resistor:

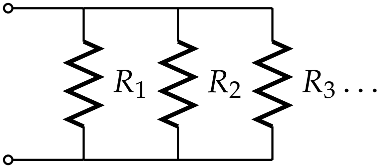
$$\boxed{P = \frac{V^2}{R}} \qquad \boxed{P = I^2 R}$$

Quantity	Symbol	SI Unit
Power	P	W (watts)
Voltage	V	V (volts)
Resistance	R	Ω (ohms)
Current	I	A (amperes)

Kirchkoff's Current Law

Kirchkoff's Voltage Law

Resistors in Parallel



From the current law, we know that the total current is the current through all the resistors, which we can rewrite in terms of voltage and resistance using Ohm's law:

$$I = I_1 + I_2 + I_3 \cdots = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3} \cdots$$

But since we also know that $V_1 = V_2 = V_3 = \cdots = V$ from the voltage law, we can re-write as

$$I = \frac{V}{R_{\text{eq}}} = V\left(\frac{1}{R_1} + \frac{1}{R_1} + \frac{1}{R_1} \cdots\right)$$

Resistors in Parallel

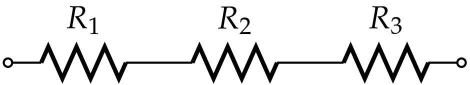
Equivalent Resistance

Through applying Ohm's Law and Kirkoff's laws, we find the equivalent resistance of a parallel circuit: **The inverse of the equivalent resistance for resistors connected in parallel is the sum of the inverses of the individual resistances.**

$$\boxed{\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_N}}$$

Quantity	Symbol	SI Unit
Equivalent resistance	R_{eq}	Ω (ohm)
Resistance of individual loads	$R_{1,2,3,\cdots,N}$	Ω (ohm)

Resistors in Series



Equivalent Resistance

Again, through applying Ohm's Law and Kirkoff's laws, we find that when resistors are connected in series: **the equivalent equivalent resistance of loads is the sum of the resistances of the individual loads.**

$$\boxed{R_{\text{eq}} = R_1 + R_2 + \cdots + R_N}$$

Quantity	Symbol	SI Unit
Equivalent resistance	R_{eq}	Ω (ohm)
Resistance of individual loads	$R_{1,2,3,\cdots,N}$	Ω (ohm)

Example Problem

Capacitors in Parallel

$$\boxed{C_{\text{eq}} = C_1 + C_2 + \cdots + C_N}$$

Capacitors in Series

Circuits with Resistors and Capacitors