

ECE 110 Transparencies

Set 0

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**These transparencies include material by
Prof. Marie-Christine Brunet and Prof. Tim Trick**

Welcome to ECE110

This is one section of the lecture, done by Prof. Haken.

You can go to either of the two sections. Homework and exams are the same! Lectures cover the same topics, but are not the same and might not be exactly synchronized.

How to reach me: See course info (e-mail is usually best)

How to get help: See course info (your instructors and TA's have office hours; also ask in 156 EL for the *red* book to sign for group study)

Please obtain:

- **Course Information Handout**
- **A copy of these transparencies (free online at courses.ece.illinois.edu/ece110/haken or sold on paper in 243 or 60 EL)**
- **Lab manual (in 243 or 60 EL)**
- **“Orange Book” Lecture notes (in 243 or 60 EL)**
- **Science notebook (bookstore or 60 EL)**
- **Tools (60 EL) (wait for your 1st lab to do this)**
- **Mallard Handout (read this very carefully)**

Make sure you know:

- **Your NETID and password**
- **How to use ECE110 web site courses.ece.illinois.edu/ece110**
- **How to find the homework deadlines and announcements**

To get the most out of this class:

- **Enjoy the labs and the hands-on experience**
- **Be excited about learning the theory and practice of ECE!**
- **Concentrate on learning material, not getting points**

To do well in this class:

- **Read topic in Orange Book before coming to class**
- **Go to lecture and ask questions**
- **Study and start on-line homework early**
No reminders will be given for homework!
- **Study in groups, meet regularly**
- **Ask for help: TAs and Profs are here to help**
- **Don't just memorize facts, understand concepts**

Avoid:

- **Missing lectures or labs**
- **Taking notes without brain engaged**
(suggestion: write comments on transparencies)
- **Missing homework assignments**
- **Waiting until weekend before exam to study**
- **All-nighters**

Check out “Research Activities” link on ECE110 web site! A team project to explore ECE – you choose the topic.

Do these things TODAY:

- Read course information handout carefully!
- Read all intro chapters to lab manual, and read Experiment 1 and Appendix A (instruments)
- Read intro to lecture notes, and read CN#0. Get familiar with some of the terminology.

ECE110 Topics

ELECTRICAL

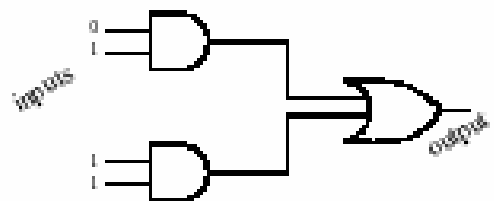
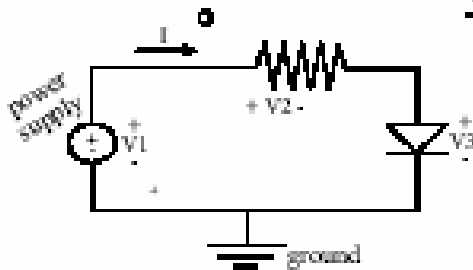
COMPUTER

Basic quantities

Current (I)
Voltage (V)

Binary numbers
(0, 1)

Circuits



Circuit Elements

Ideal sources
Resistances
Diodes
Transistors
Capacitors
Inductors

Basic gates
AND
OR
NOT
Basic Logic Blocks

In the lab your team will design an autonomous vehicle that can follow a path marked by a reflective tape.

Your team can also take part in an optional contest.

Most lecture topics will help you understand elements of the vehicle design. Some additional lecture topics will introduce other areas of ECE.

ECE110 Electrical Engineering Topics:

- **Power, Energy, and Resistance**
- **Basic Circuit Laws (Ohm's law, Kirchhoff's laws)**
- **Circuit Analysis (IV characteristics, Thevenin/Norton)**
- **Motors (DC Motor used in lab)**

ECE110 Computer Engineering Topics:

- **Digital Circuit Analysis (Boolean expressions, Truth Tables, Timing Diagrams)**
- **Logic Design**
- **Logic Blocks (MUX, Comparator)**
- **Sequential circuits (Flip-flop, Register , Counter)**
- **Other Topics (Sampling, Quantization, A/D and D/A Converters, Information Coding, Compression, Error Detection, Encryption)**

General ECE110 Goals are to help you:

- **Decide on your major**
- **Understand ECE concepts**
- **Develop good study habits**
- **Develop critical thinking**
- **Develop a love and curiosity for ECE**
- **Apply ethics in engineering**

Charge and Current

Smallest amount of charge: Charge of one electron.

$$q = -1.6 \times 10^{-19} \text{ C}$$

For a proton the charge is $-q$.

Like charges repel, opposites attract.

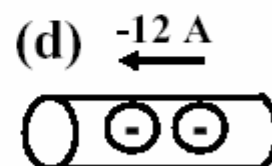
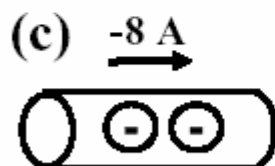
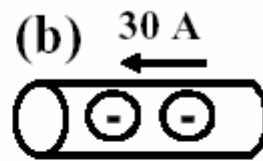
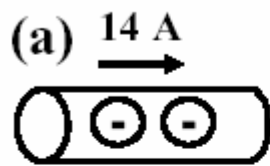
Current is moving charges, measured in Amperes.

$$I = \frac{dQ}{dt}$$

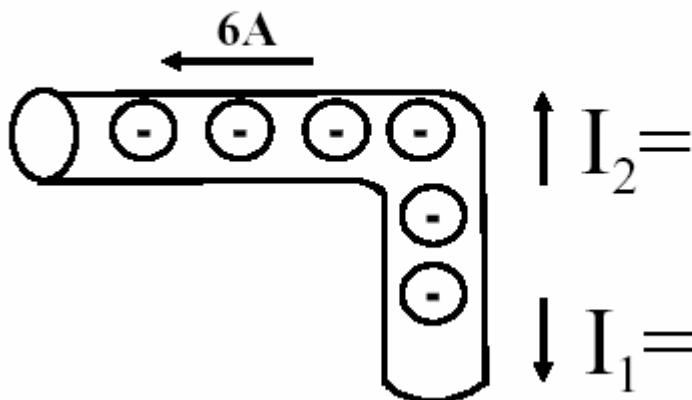
$$1\text{A} = 1\text{C}/1\text{s}$$



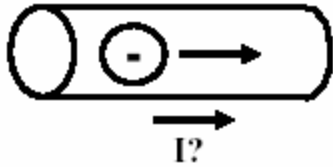
1. Show the direction of the electrons:



2. Give the numerical value of the shown currents I_1 ; I_2



In a wire 10^{20} electrons per second are moving to the right



Total charge movement per second:

$$\Delta Q = \underbrace{-1.6 \times 10^{-19}}_{\text{electron charge}} \times 10^{20} = -16\text{C}$$

Current:

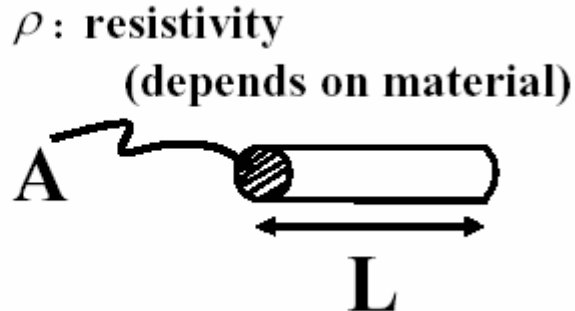
$$I = \frac{\Delta Q}{\Delta t} = \frac{-16\text{ C}}{1\text{ s}} = -16\text{A}$$

Resistance and Voltage

Resistance is the ability of a conducting material to resist the flow of charge (current). Ideal wires have no resistance.

$$R = \rho \times \frac{L}{A}$$

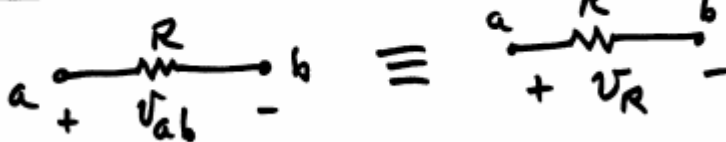
unit: Ω (Ohm)



Voltage is the unit of electromotive force.

$$V = I \times R$$

Voltage Notation



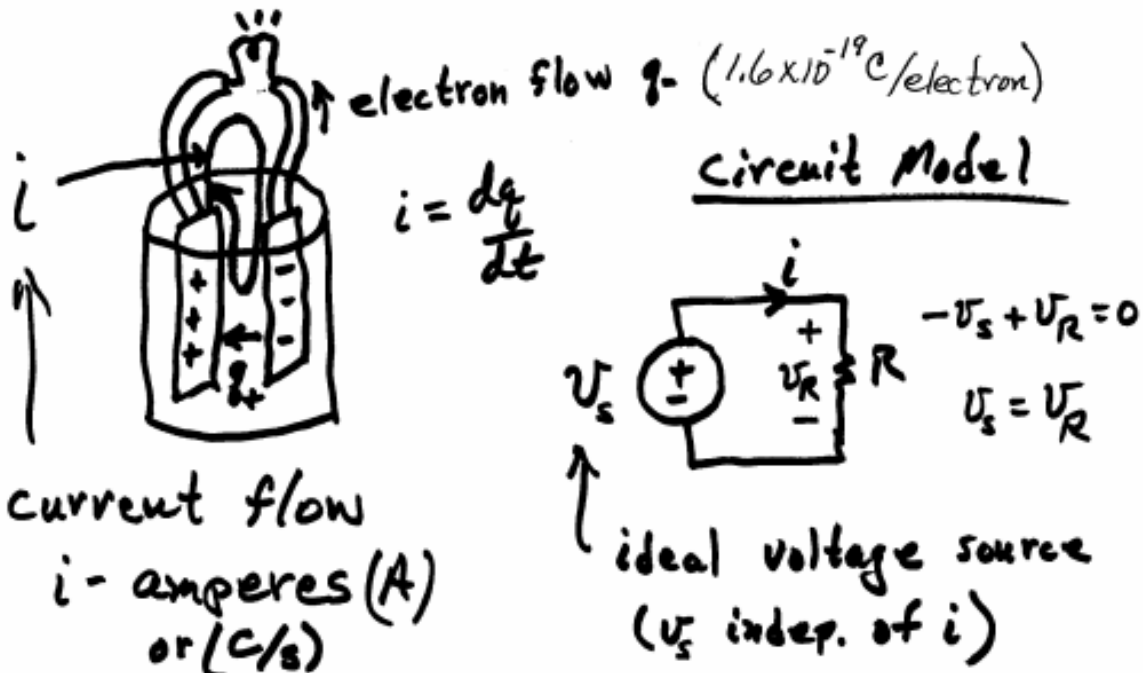
$$V_{ab} = -V_{ba}$$

Current flows from higher voltage to lower.

Electrical Circuits

Current can only flow in a closed circuit.

No current flows in an open circuit.

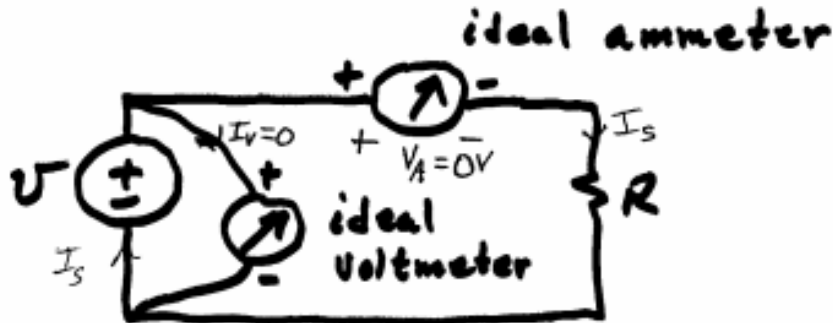


One point in the circuit is used as a voltage reference, or ground.

A voltage source may supply a constant voltage, or the voltage may be a function of time.

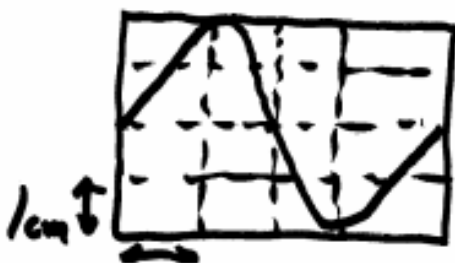
Is a battery a constant voltage source, or a function of time?
What about a electrical outlet on the wall?

Ammeters and Voltmeters



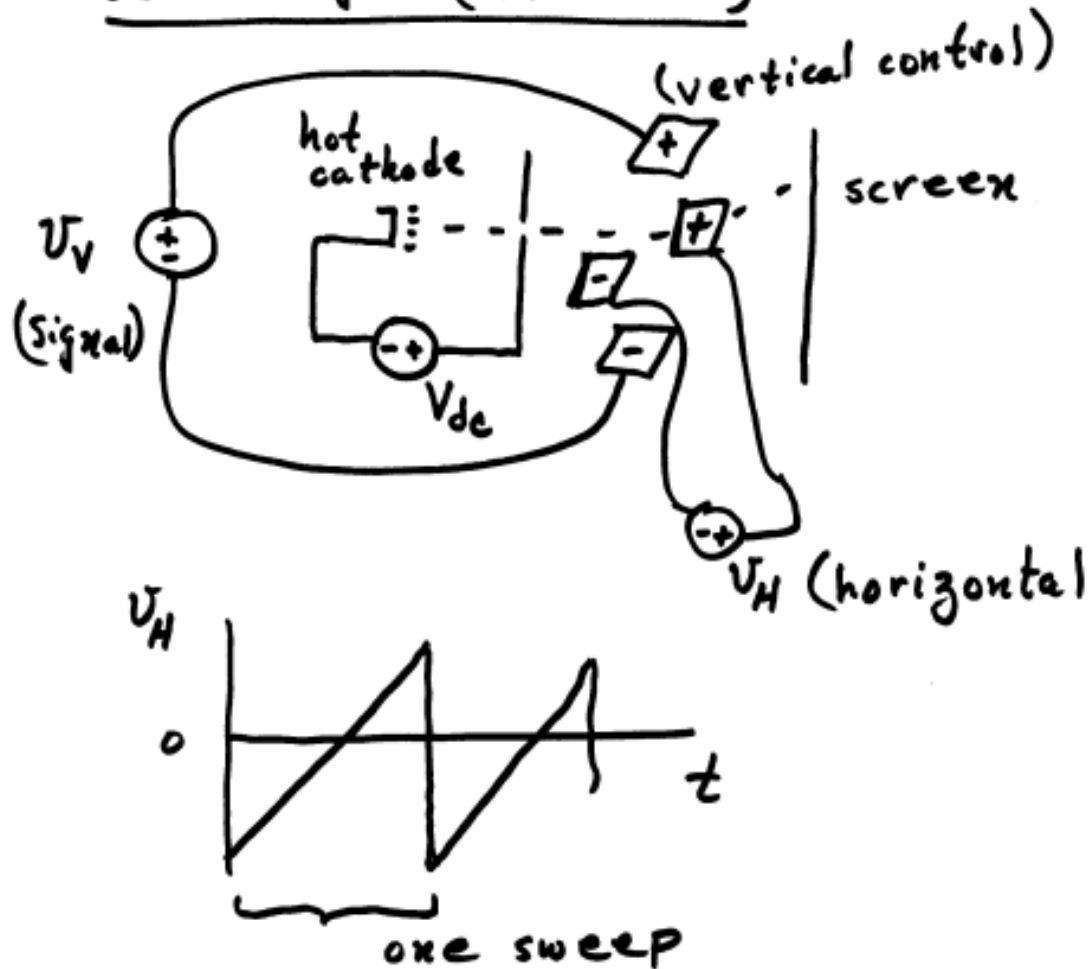
ideal voltmeter has infinite resistance!
 ideal ammeter has zero resistance!

Oscilloscope - ideal voltmeter that displays voltage as a function of time.

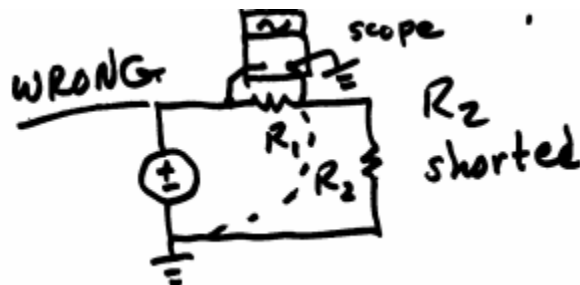


horizontal = 2.5ms/cm
 vertical = 5V/cm

Oscilloscope (continued)



Be careful when hooking up oscilloscope probes in the lab. Each probe has two connections: a signal connection and a ground. The tip can measure any point in your circuit, but the ground can only be connected at your circuit ground, else a short circuit will occur.

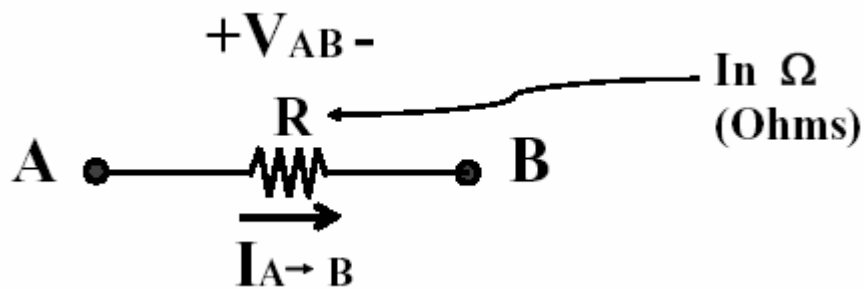


Power and Polarity

Power is measured in units of Watts:

$$P = I \times V$$

When computing power, you need to be careful of polarity of V and direction of I . In circuit diagrams, the polarity of V is often indicated with a $+$ and $-$; the direction of I is indicated with an arrow.



(As drawn, this is an open circuit, so no current could flow – but assume this is part of a bigger circuit.)

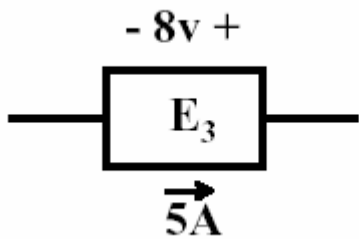
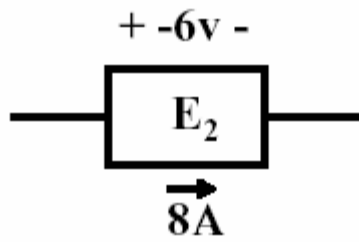
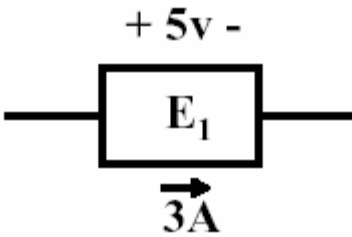
The above power equation will tell you how much power is dissipated if you are using the Standard Reference System – in other words, if the polarity of V and direction of I agree.

The polarity of V and direction of I agree when:

**I flows from the voltage $+$ mark
to the voltage $-$ mark**

If the polarity of V and I disagree, then you need negate I or V before you use the equation above.

The following examples show an element E , with voltage change across the element, and a current flowing through the element



Loads and Sources

A load dissipates energy.

If $V_A = 25\text{V}$, $V_B = 10\text{V}$, $R = 10\text{ ohms}$, compute I and P :
(Start by marking V_{AB} and the $+$ and $-$ polarity marks)



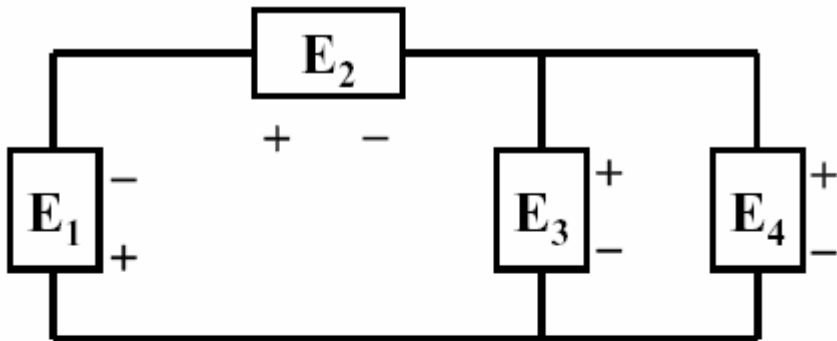
A source generates energy (also called a power supply).

Mark voltages and currents below,
compute the power dissipated by the resistor,
and compute the power of the source.



The power equation gives a negative value for the source.

Find E_4 using conservation of energy (sum of all powers has to be 0):



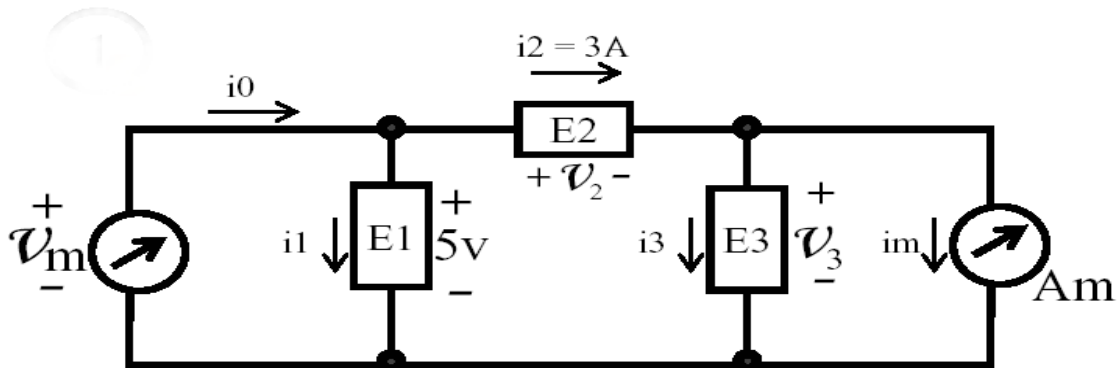
$$P(E_1) = -30W$$

$$P(E_2) = 10W$$

$$P(E_3) = 5W$$

$$P(E_4) =$$

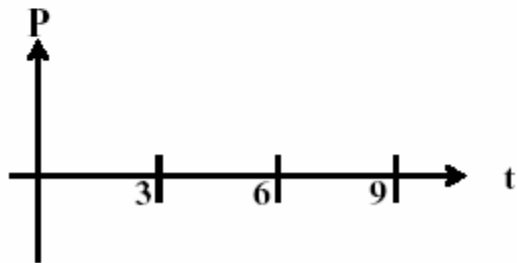
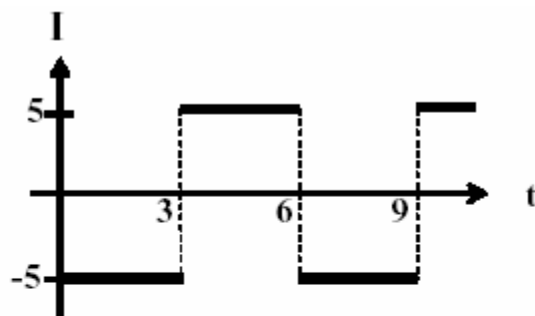
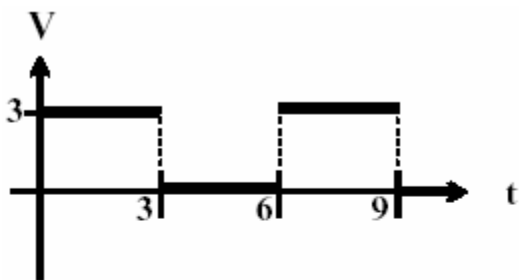
Solving a circuit means finding voltages and currents across all elements in the circuit. Solve this circuit:



Average Power

Find the average of $I \times V$ to compute average power. Make sure you compute it for one period of a repeating signal.

:



$P_{\text{aver}} =$

Note: $P_{\text{aver}} \neq I_{\text{aver}} \times V_{\text{aver}}$

RMS

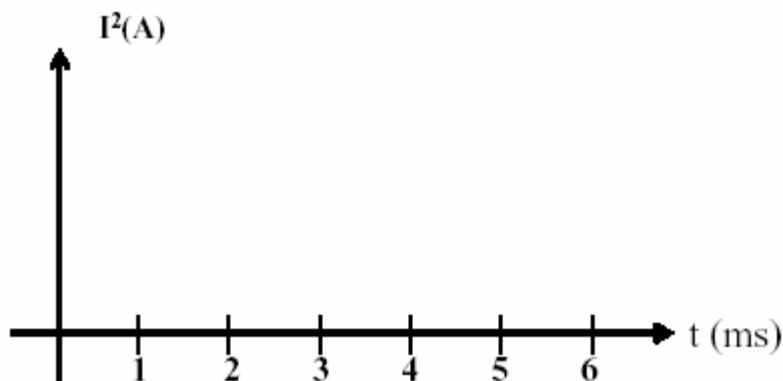
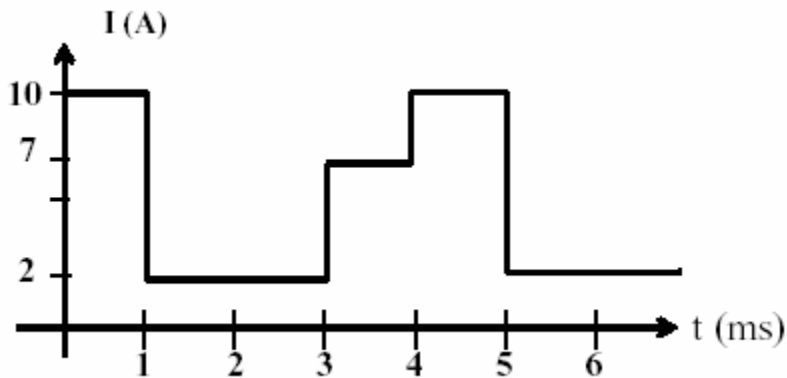
The RMS value is based on one period of a repeating waveform:

$$\text{RMS } (x(t)) = \sqrt{\text{average } [x^2(t)]}$$

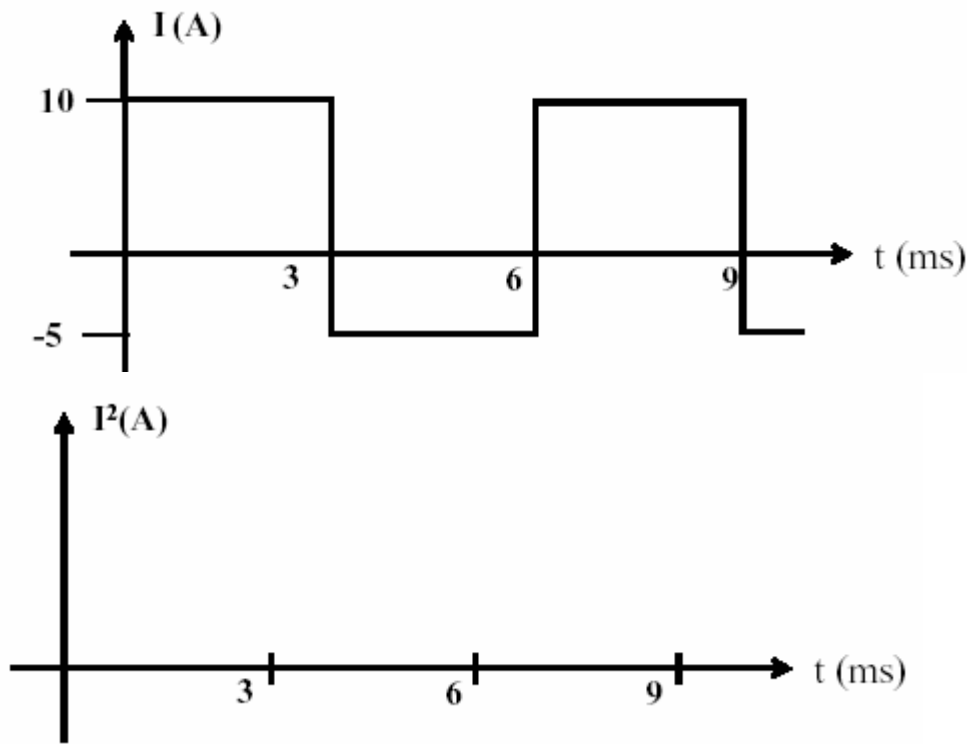
Root Mean Square

$$\text{If } V = I \times R, \quad P_{\text{aver}} = I_{\text{RMS}} \times V_{\text{RMS}}$$

Compute RMS current for:
(First figure its period.)



Compute RMS current for:



RMS is often used in Audio. An audio signal with the same peak voltage as another may sound much louder or much quieter. Why? Why does RMS voltage tell you more than peak voltages about the signal loudness?

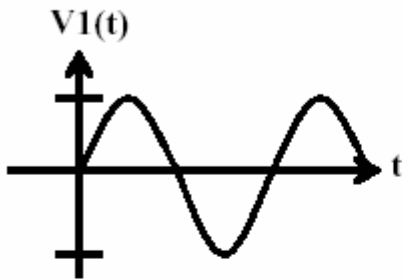
RMS for Sinusoidal Signals

The RMS value for a sinusoidal signal without offset (AC signal) is:

$$\text{RMS}_{\text{AC}} = \text{Peak} \div \sqrt{2}$$

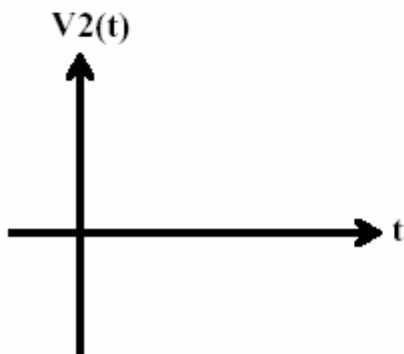
Ex. 1 $V_1(t) = 7\sin(\omega t)$ volts

↙ in radians



Peak value =
Peak-to-Peak =
Period T =
Frequency f =
Offset =

Ex. 2 $V_2(t) = 3 + 2\sin(\pi t)$



Peak =
P-to-P =
T =
f =
Offset =

What is V_{RMS} for example 1?

In the circuit below,

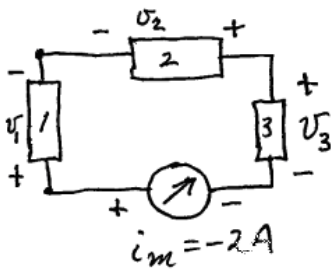
$$v_1 = 3\text{V}$$

$$v_2 = -5\text{V}$$

$$v_3 = -8\text{V}$$

$$i_m = -2\text{A (current through the ideal ammeter)}$$

Calculate power for each component, and state whether the component is supplying or absorbing energy.



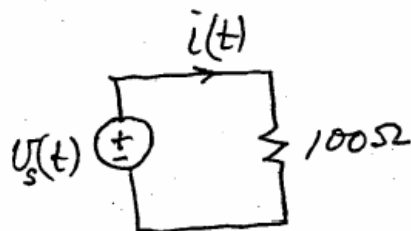
$$P_1 = v_1 i_m = \boxed{} \quad \underline{\hspace{2cm}}$$

$$P_2 = v_2 i_m = \boxed{} \quad \underline{\hspace{2cm}}$$

$$P_3 = v_3 i_m = \boxed{} \quad \underline{\hspace{2cm}}$$

2. If $v_s(t) = 170 \sin 2\pi \cdot 60t$

Find rms values of v_s and i and the average power dissipated in the resistor.

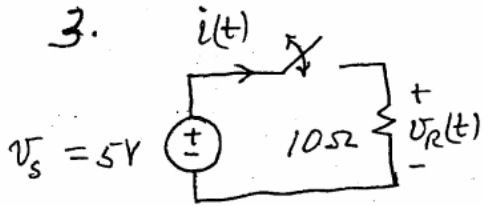


$$V_{s\text{rms}} = \boxed{}$$

$$I_{\text{rms}} = \boxed{}$$

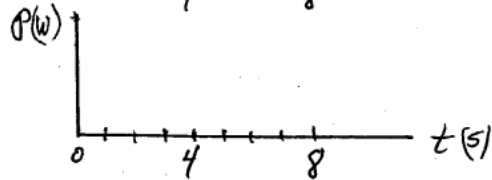
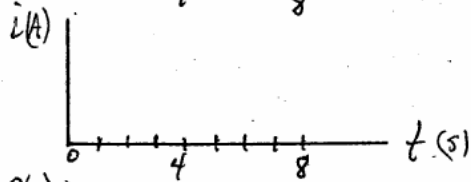
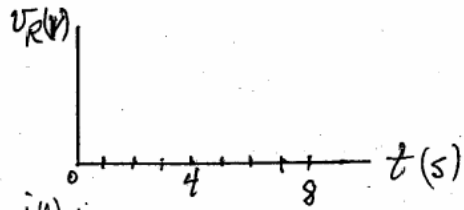
$$P_{\text{avg}} = \boxed{}$$

3.



switch cycle: (1s closed)
(7s open)

Sketch v_R , i , and p . Find V_{rms} , V_{Rrms} , and I_{rms} and P_{avg} .



$V_{rms} =$

$V_{Rrms} =$

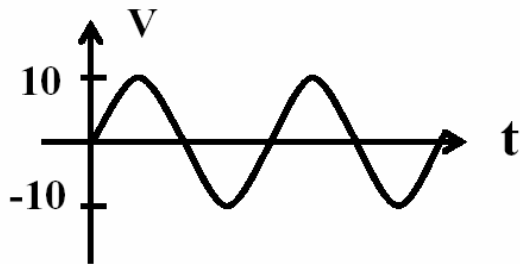
$I_{rms} =$

$P_{avg} =$

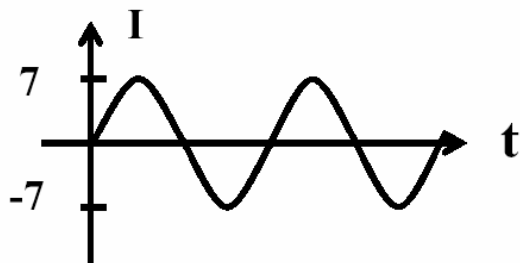
$P_{avg} \neq V_{rms} I_{rms}$ why?

4. Find the average power.

(Remember: $P_{\text{aver}} \neq I_{\text{aver}} \times V_{\text{aver}}!$)



V average =



I average =



Energy

The most common symbol used for energy is **E**.
The unit of energy is **J (Joule)**.

In General: $P = dE/dt$

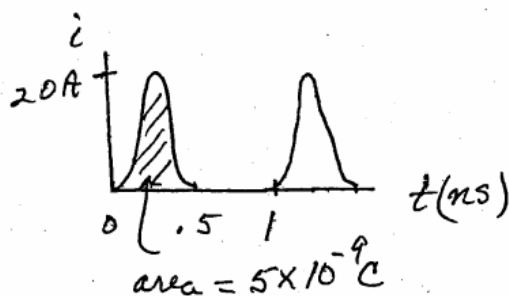
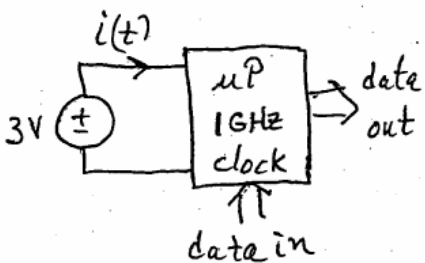
$$\boxed{E(t_0)} = \int_0^{t_0} P(t) dt$$

For a periodic signal:

$$\boxed{E(T)} = \int_0^T P(t) dt$$

$$\Rightarrow E = \left[\frac{1}{T} \int_0^T P(t) dt \right] \times T \Rightarrow E = P_{\text{average}} \times T$$

1. Given the current waveform and area (total charge) for one cycle, calculate the average power dissipated by the microprocessor.



$P_{avg} =$