2014 Science Olympiad Clinic

Region 7

Jan 9, 2014

Circuit Lab

David Hein

dhein@lear.com

What to Include in your Binder – Division C

- “1 Page” Cheat Sheet – Quick reference
- Units and constants
  - M, m, k, p, n, …
  - Resistivity
  - Derivation of SI Units
- Detailed sections
  - Basic DC
  - Battery
  - Types of components
  - Basic Circuits
  - Sections for different circuit analysis; Mesh, Nodal, Thevenins, Norton,
  - Conversion of units
  - Wheatstone Bridge
  - Capacitor Theory
  - **History**
  - **Digital Logic**
- Definitions

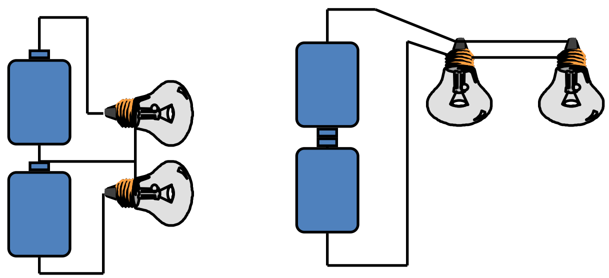
Div. C Topics

- DC circuit concepts, definitions and principles
  - Voltage, Current, EMF, Resistance
  - Series, Parallel
  - Voltage Dividers
  - Impedance Matching
  - History

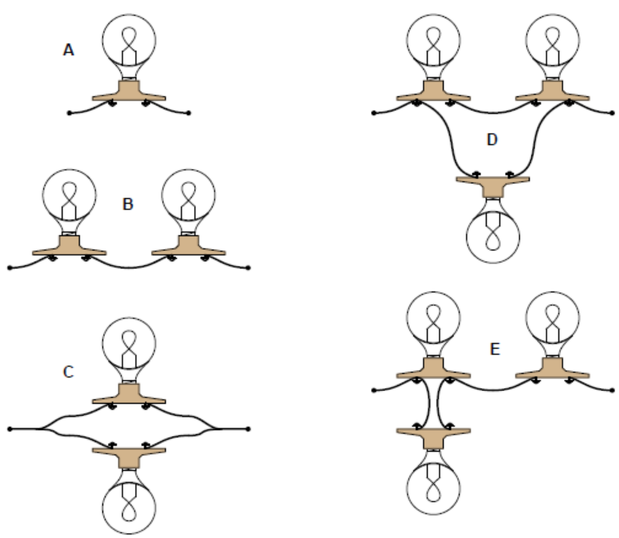
Possible Types of Problems

SCIENCE OLYMPIAD
Exploring the World of Science

- Battery polarity

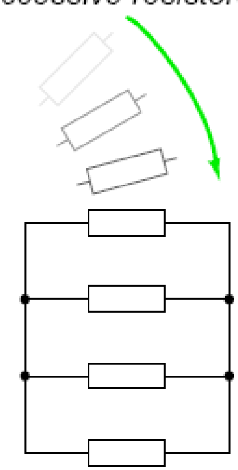


- Parallel versus series



Describe what ill happen to the total resistance and conductance when you add additional resistors in parallel

Adding successive resistors in parallel



History

- Named SI Units only
  - Ohm
  - Volt
  - Ampere
  - Henry
  - Coulomb
  - …. (this is not a complete list)
- Who, When, Why, What style of questions
- Related Laws

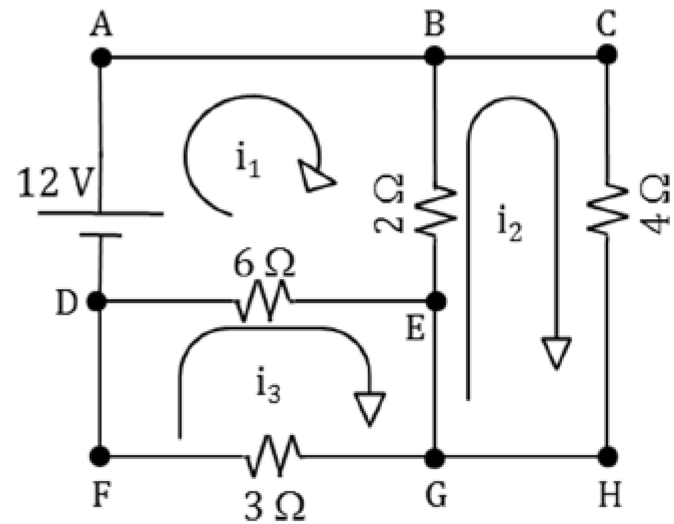
Name[3][4]	Life	Nationality	Quantity[5]	SI unit[Note 2]
André-Marie Ampère[6]	1775–1836	French	Electric current [7]	(Base unit)
William Thomson, 1st Baron Kelvin[8]	1824–1907	British (Scottish)	Thermodynamic temperature[9]	(Base unit)
Blaise Pascal[10]	1623–1662	French	Pressure[11]	pascal (Pa)
Isaac Newton[12]	1643–1727	British (English)	Force[13]	newton (N)
Anders Celsius[14]	1701–1744	Swedish	Temperature[15]	degree Celsius (°C)
Charles-Augustin de Coulomb[16]	1736–1806	French	Electric charge[17]	coulomb (C)
James Watt[18]	1736–1819	British (Scottish)	Power[19]	watt (W)
Alessandro Volta [20]	1745–1827	Italian	Electric potential[21]	volt (V)
Georg Simon Ohm[22]	1789–1855	German	Electrical resistance[23]	ohm (Ω)
Michael Faraday[24]	1791–1867	British (English)	Capacitance[25]	farad (F)
Joseph Henry[26]	1797–1878	American	Inductance[27]	henry (H)
Wilhelm Eduard Weber[28]	1804–1891	German	Magnetic flux[29]	weber (Wb)
Ernst Werner von Siemens [30]	1816–1892	German	Conductance[31]	siemens (S)
James Prescott Joule[32]	1818–1889	British (English)	Energy[33]	joule (J)
Antoine Henri Becquerel[34]	1852–1908	French	Radioactivity[35]	becquerel (Bq)
Nikola Tesla [36]	1856–1943	Serbian[Note 3]-American	Magnetic flux density[37]	tesla (T)
Heinrich Rudolf Hertz[38]	1857–1894	German	Frequency[39]	hertz (Hz)
Rolf Maximilian Sievert[40]	1896–1966	Swedish	Dose equivalent of radiation[41]	sievert (Sv)
Louis Harold Gray [42]	1905–1965	British (English)	Absorbed dose of radiation[43]	gray (Gy)
John Napier[44]	1550–1617	British (Scottish)	Magnitude (natural logarithmic) [45]	neper (Np)
Alexander Graham Bell[46]	1847–1922	British (Scottish)-American	Magnitude (common logarithmic)[47]	bel (B)
Hans Christian Ørsted	1777-1851	Danish	Magnetic field	oersted (Oe)
Johann Carl Friedrich Gauss	1777-1855	German	Magnetic flux density	gauss (G)
James Clerk Maxwell	1831-1879	British (Scottish)	Magnetic flux	maxwell (Mx)

Div. C Topics

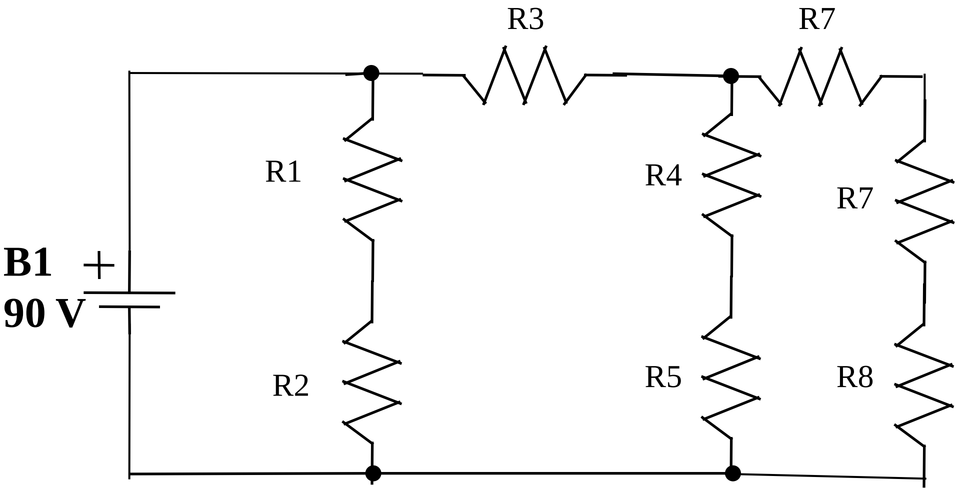
- DC circuit analysis theory
  - Ohms Law, Parallel, Series
  - Krichhoff's KCL, KVL
  - Node and Mesh Analysis
  - Norton and Thevenins equivalent

Possible Types of Problems

6. For the circuit shown below



a. Conduct the mesh analysis for Mesh ABEDA and Write down the equation.



Complete the below table

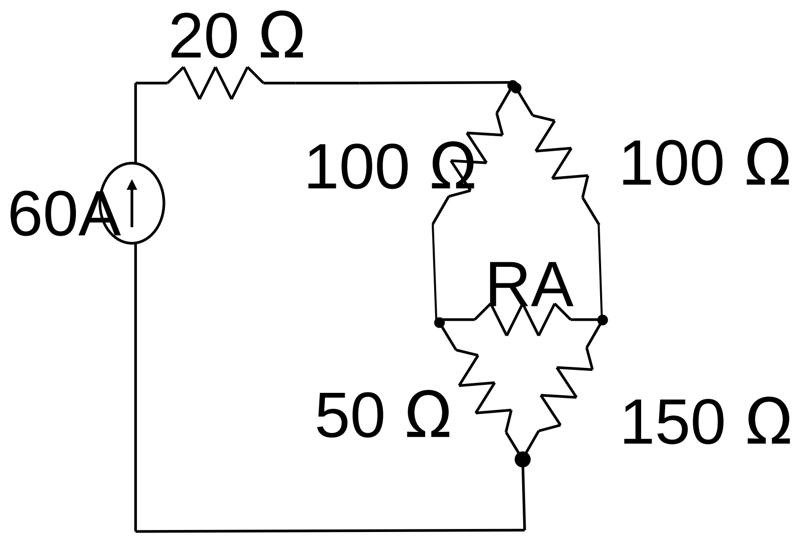
Resistor Number	Resistor Color Codes	Resistance	Voltage	Current	Power
R1	Red Green Black Gold	25 Ohms	**25 V**	1 Amp	**25W**
R2	Blue Green Black Gold	**65 Ohms**	**65 V**	**1 A**	**65W**
R3	Orange Black Black Gold	**30 Ohms**	**30 V**	1 Amp	**30W**
R4	Orange Black Black Gold	30 Ohms	15 Volts	**0.5 A**	**7.5 W**
R5	White Black Black Gold	**90 Ohms**	**45 V**	**0.5 A**	**22.5 W**
R6	Yellow Black Black Gold	**40 Ohms**	**20 V**	0.5 Amps	10 Watts
R7	Yellow Black Black Gold	40 Ohms	**20 V**	**0.5 A**	**10 W**
R8	Yellow Black Black Gold	40 Ohms	**20 V**	**0.5 A**	**10 W**
B1	XXXXXXXXX	XXXXXXXXX	90 Volts	**2 A**	**180W**

(0.5 Points per Blank)

Div. C Topics

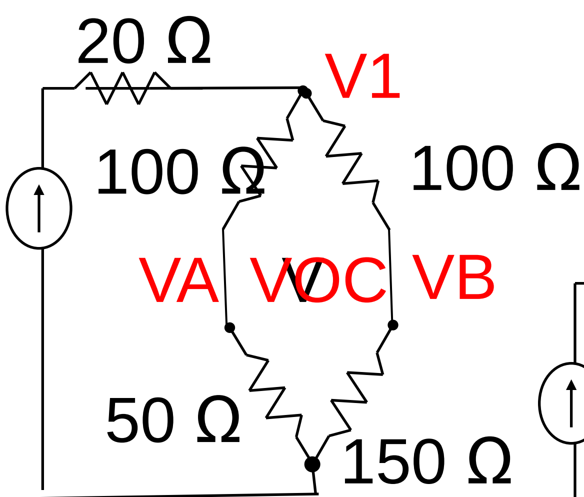
- DC circuit analysis practice
  - Meter Usage
    - How do meters work
  - Color Codes
  - Wheatstone Bridges

Use Norton's theorem to give the current through RA for the different resistor values of RA



RA Value	Current
20 Ω	20 A
50 Ω	15 A
100 Ω	10.5
150 Ω	4.84

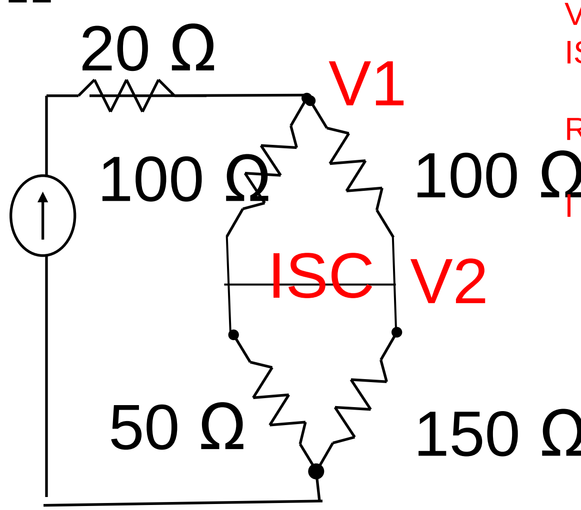
Req = 20 + 1/ (1/(100+50)+1/(100+150)) = 113.7 Ohms
Vin = 6825V
V1 = Vin – 60 * 20 = 6705V
VA = V1*50/ 150 = 2235V
VB = V1 * 150/250 = 4203V
Voc = VB – VA = 1788V

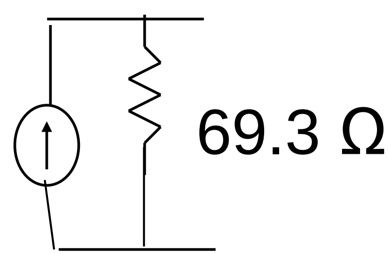


Req = 20 + 50+ 1/(1/50+1/150) = 107 Ohms
Vin = 6450V
V2 = Vin *37.5/107.5 = 2250
V1 = Vin -120 = 6330 V
ISC = (V1-V2)/100 – V2/150 = 40.8 A – 15A = 25.8A

Rth = Voc/ISC = 69.3 Ohms

I = ISC * 69.3/(69.3+ RA) =

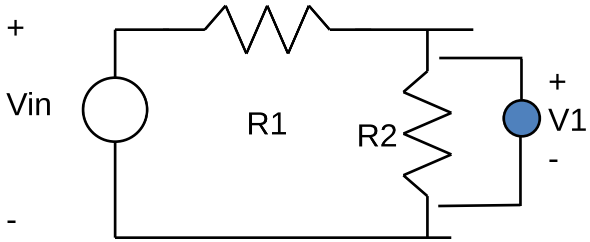




(10 Points)

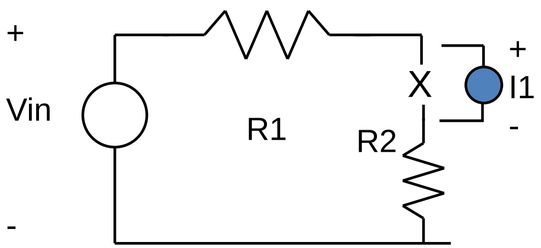
Using Meters

SCIENCE OLYMPIAD
Exploring the World of Science



Measure Voltage

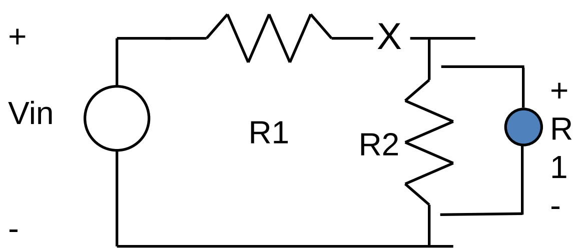
Voltage is measured across a component. Otherwise known as a voltage drop across the component. The meter is connected in parallel with the component to be measured.



Measure Current

Current is measured as a flow through a component. In order to measure current through a component, you will have to disconnect the circuit and hook the meter in series with the component to measure the current through.

Watch for Short Circuit



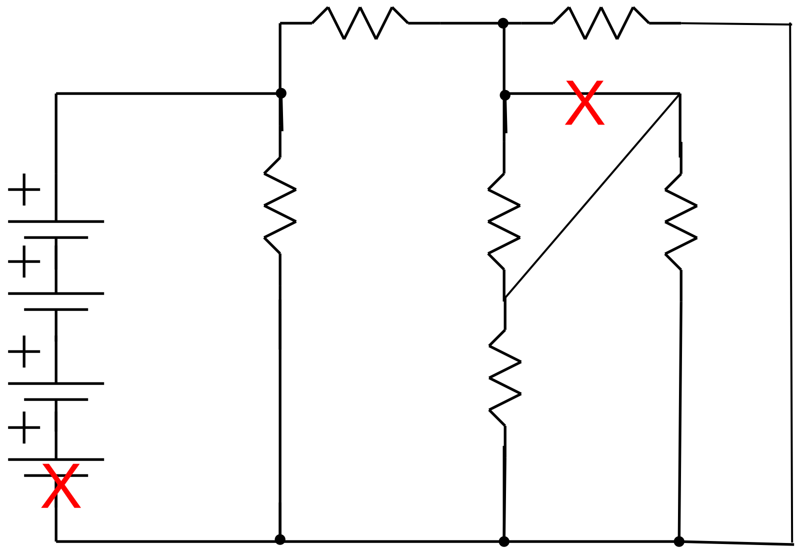
Measure Resistance

Resistance is measured across a component. The meter is connected in parallel with the component to be measured. In order to accurately measure the resistance, you should disconnect other components to prevent them from interfering with your reading.

Find The problems with the Circuit

SCIENCE OLYMPIAD
Exploring the World of Science

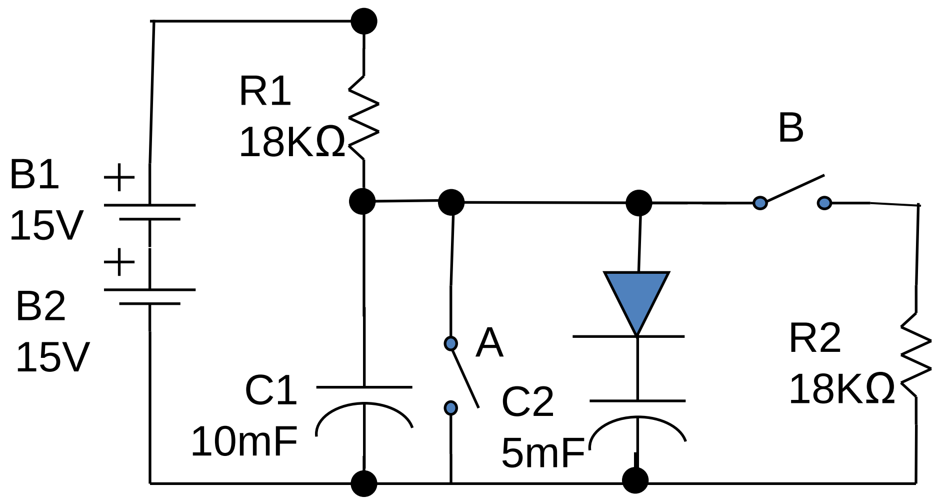
The circuit in this station was to be built per the below schematic, but, the circuit was built incorrectly.
Measure and calculate the circuit voltages.
Use a comparison between the measured values and the calculated values to determine which component or components of the circuit has been built incorrectly.



(25 Points)

Div. C Topics

- Intermediate DC circuits concepts, definitions and principles (including diodes and capacitors)
  - SI Units and derived units
  - Capacitance and RC Circuits
  - Ideal Diodes
  - Electron current
  - Digital Logic



Initially, Switch A is shorted, Switch B is open and there is no charge on the capacitors. At time T = 0, Switch A opens. Next at Time T= 1 second, Switch B closes. Finally at time T = 2 seconds Switch A closes.
Make a plot of the voltage on C1 and C2 over time indicating the voltage of the capacitors just before and just after each switch change.
Calculate the capacitor charging or discharging constant for each of the conditions.

At T=0, C1, and C2 are in parallel, final target voltage is 30 Volts; time constant is 15mF * 18k = 270 s.

VC1, C2 = (V-Vi)* (1-e –t/tc) + Vi

C1

At T = 1; Vi =0, tc = 270 s, V = 30

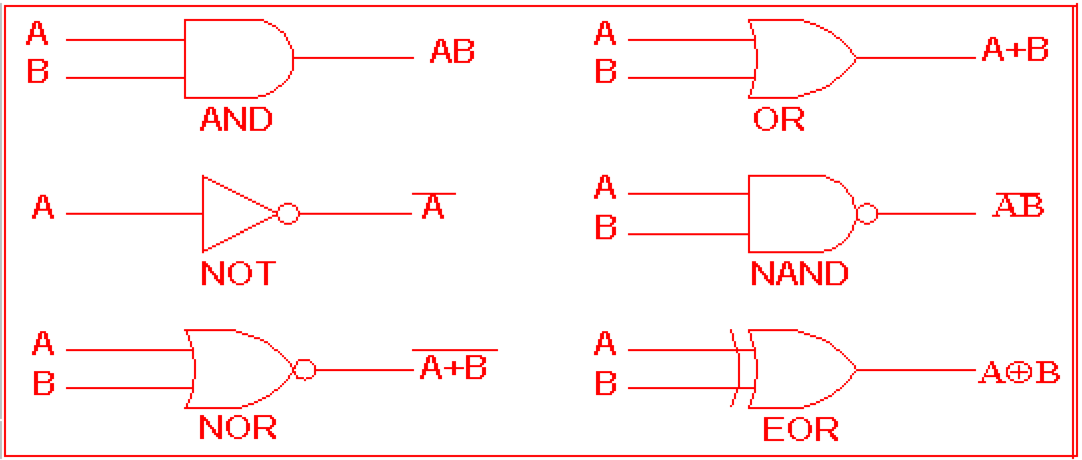
VC1, C2 = (30)* (1- e –1/270) + 0 = 0.11 V

Between t=1 and t = 2; Vi = 0.11V; V = 15 V; tc = 270 s; t = 1

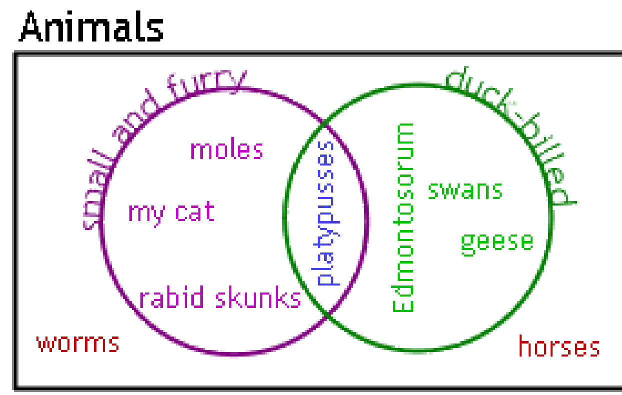
VC1, C2 = (15-0.11)* (1- e –1/270) + .11 = 0.16 V

At t=2; C1 is shorted; charge stays on C2 because of the

Digital Logic



Logic Gates



Venn Diagram

Inputs A	Inputs B	AND	OR	Outputs NAND	NOR	EOR
0	0	0	0	1	1	0
0	1	0	1	1	0	1
1	0	0	1	1	0	1
1	1	1	1	0	0	0

Truth Table

$$A = \overline{B} \cdot (C \cdot (\overline{D} + E + C) + \overline{F} \cdot C)$$

$$A = \overline{B} \cdot (\overline{D} \cdot C + E \cdot C + C \cdot C + \overline{F} \cdot C)$$

$$A = \overline{B} \cdot (\overline{D} \cdot C + E \cdot C + C + \overline{F} \cdot C)$$

$$A = \overline{B} \cdot C \cdot (\overline{D} + E + 1 + \overline{F})$$

$$A = \overline{B} \cdot C \cdot (1)$$

$$A = \overline{B} \cdot C$$

Boolean Algebra

Suggested References

- Websites:
  - Soinc.org Shock Value / Circuit Lab Event pages
  - Scioly.org student forums / wiki / test exchange
  - Wikipedia (Electrical Circuit, Magnetism, etc.)
  - Ibiblio (Lessons in Electric Circuits, Volumes I,V and VI)
  - Youtube (Intro to electricity, Principles of Electricity)
  - http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc
  - http://www.khanacademy.org/#Physics
- Books:
  - Science / Physics textbooks – most have chapters on this material
  - Electric Circuits, James W. Nilsson

Hands On / Fun Stuff

- Kits and parts
  - www.Sparkfun.com electronics kits, books
  - http://www.elenco.com/ electronics kits
  - http://www.kelvin.com/ Parts and kits – many subjects

- YouTube 2000 V demonstration
  - http://www.youtube.com/watch?v=8hwLHdBTQ7s&feature=youtube_gdata_player