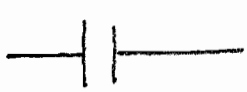
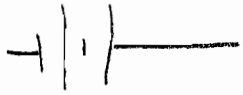
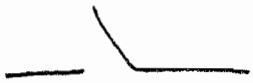
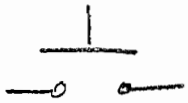
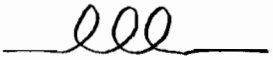
Shock Value
JC Booth Invitational, 1/22/11

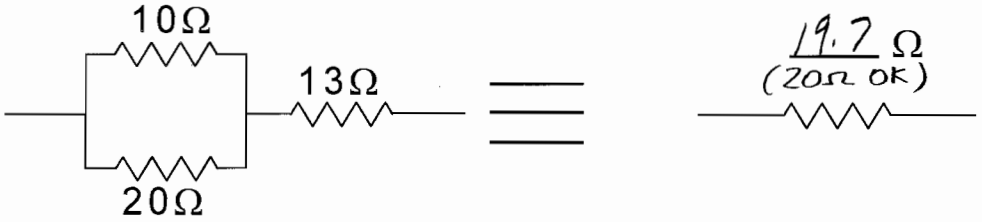
Team Name: _____ Score: _____

Team Members: _____

1) Please give the schematic symbol for each item listed below

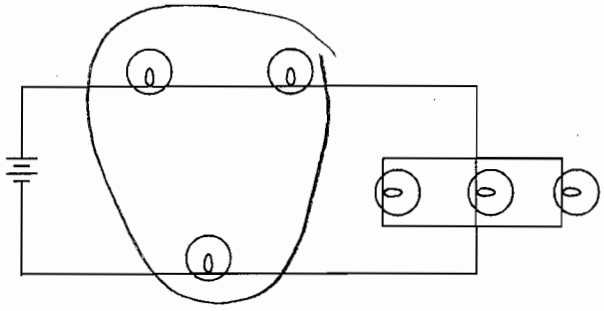
Resistor	Variable resistor	Capacitor	Battery
			
Switch	**Ammeter**	**Push button**	**Coil**
			

2) What is the equivalent resistance of the circuit below?



19.7 Ω
(20Ω OK)

3) The six bulbs below are identical. Circle the three that will burn brightest.



4) A battery converts CHEMICAL energy into ELECTRICAL energy.

5) A motor converts ELECTRICAL energy into MECHANICAL energy.

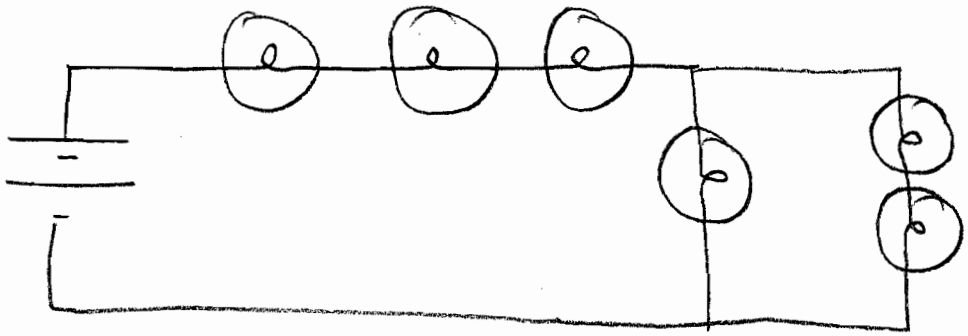
6) A generator converts MECHANICAL energy into ELECTRICAL energy.

7) In a circuit, resistance is measured with what device? OHMMETER

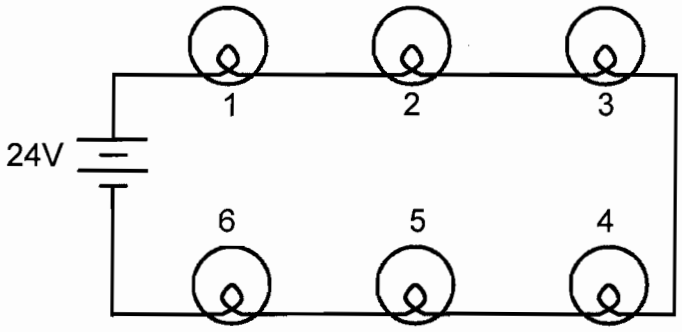
8) In a circuit, current is measured with what device? AMMETER

9) In a circuit, voltage is measured with what device? VOLTMETER

10) You are given 6 identical lightbulbs and a power supply. Draw a schematic showing how you would connect the bulbs so that three burn very brightly, one less bright, and two even less bright.



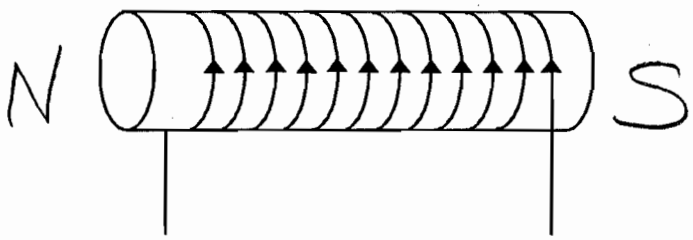
11) The short string of Christmas lights below is made up of three different types of bulbs. If bulbs 1 and 4 each have X resistance, bulbs 2 and 5 each have 2X resistance, and bulbs 3 and 6 each have 3X resistance, what is the voltage drop across each bulb?



V1= 2V V4= 2V
V2= 4V V5= 4V
V3= 6V V6= 6V

12) In the circuit above, if 0.78A is flowing through each bulb, what power is being dissipated in the circuit?
19W

13) A coil of wire is wrapped around a metal bar as shown below. Conventional current flow is in the direction of the arrows. Please label which end of the bar will be a north pole and which end will be a south pole.



14) What are the commonly used units for ... (Please spell out, i.e., no symbols)
a. Current AMPS, AMPERES
b. Voltage VOLTS
c. Resistance OHMS
e. Power WATTS
f. Magnetic field strength TESLA, GAUSS, A/m

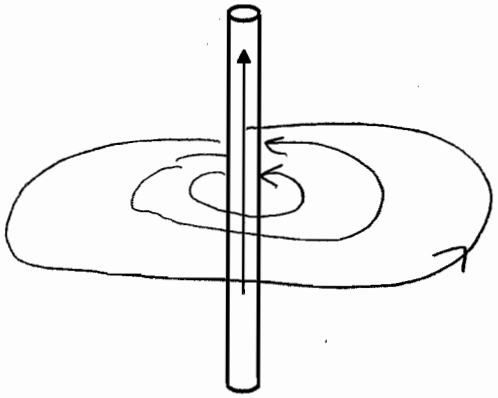
15) What are three elements capable of being permanently magnetized? FE, NI, Co
(IRON, NICKEL, COBALT)

16) Name three materials that can be used for battery electrodes. BASICALLY, ANY METAL. TWO DISSIMILAR METALS FOR ONE BATTERY

17) List two ways to magnetize a permanent magnet. PLACE IN STRONG MAGNETIC FIELD, HOLD IN N/S DIRECTION AND STRIKE HARD, PASS ELECTRICAL CURRENT THROUGH IT

18) List two ways to de-magnetize a permanent magnet. PUT IN OPPOSITE MAGNETIC FIELD, HEAT BEYOND CURIE POINT, STRIKE WHILE OUT OF ALIGNMENT WITH N/S FIELD

19) Conventional current flow in a long wire is shown below by the arrow. Please draw the resultant magnetic field.



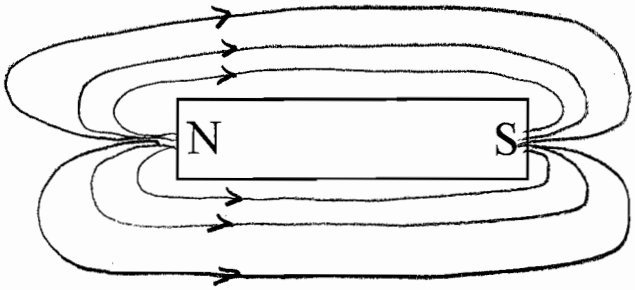
CIRCULAR FIELD PERPENDICULAR TO WIRE

20) The magnetic field strength of a solenoid is a function of its permeability, THE NUMBER OF TURNS and CURRENT.

21) What is a dry cell? THE ELECTROLYTE IS A PASTE. ORIENTATION OF BATTERY WON'T AFFECT OPERATION OR CAUSE LEAKAGE.

22) What is a wet cell? ELECTROLYTE IS A LIQUID. ORIENTATION COULD CAUSE LEAKAGE AND FAILURE.

23) Please draw several magnetic field lines for the bar magnet below.



FLOW FROM N TO S POLE

24) The strongest permanent magnetic material is (circle one):
a. AlNiCo
b. Fe
c. NdFeB
d. SmCo

25) The insulator between two plates of a capacitor is called (circle one)
a. Electrolyte
b. Dielectric
c. Insulator
d. Spacer

25) What is the unit of capacitance? FARAD

26) What is the unit of inductance? HENRY

27) The unit of electrical charge is the Coulomb. What is the charge of a proton? 1.602×10^{19} COULOMBS

28) The unit of electrical charge is the Coulomb. What is the charge of an electron? -1.602×10^{-19} COULOMBS

29) The capacitance between two plates is proportional to the relative permeability of the material between the plates and the AREA OF THE PLATES and inversely proportional to the DISTANCE BETWEEN THE PLATES

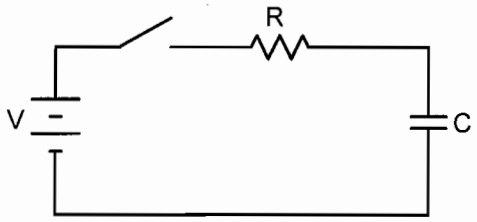
30) The anode of the battery is the (circle one)
- a. Current carrying medium
- b. Electrolyte
- c. Negative electrode
- d. Positive electrode

31) Electric current that flows from negative to positive is called (circle one)
- a. Conventional current flow
- b. Electron current flow
- c. Energy flow
- d. Ionic current flow

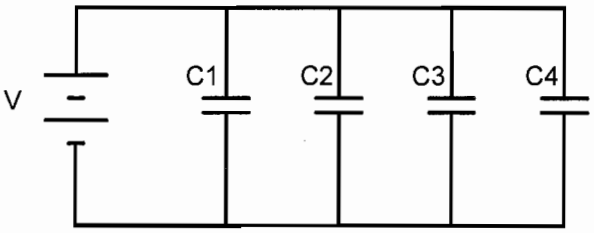
32) The cathode of the battery is the (circle one)
- a. Current carrying medium
- b. Electrolyte
- c. Negative electrode
- d. Positive electrode

33) Electricity can be considered (circle one)
- a. Charged particles
- b. Dipoles
- c. Electrodes
- d. Magnetic charges

34) In the circuit below, V = 12VDC, R = 200Ω, and C = 12μF. If the switch closes at time t = 0, how long will it be before the capacitor is fully charged? ≈ 12mS (0.012 Sec)



35) In the circuit below, V = 24VDC, C1 = C2 = 10μF, and C3 = C4 = 20μF. The four capacitors can be replaced with one that has a value of 60μF



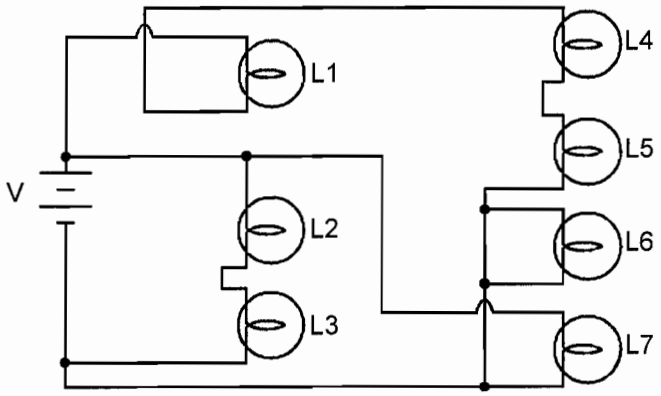
36) The small groups of atoms that behave like small magnets inside a large magnet are called (circle one)
- a. Iron filings
- b. Domains
- c. Poles

37) An LR circuit has a resistor value of 1.5kΩ. If the time constant is 0.243mS, what is the inductance value? 0.365H (365mH)

38) What is the capacitance if a capacitor uses a dielectric with k = 1.324, an area of 12mm², and plates separated by a distance of 0.02mm? 7×10^{-12} F = 7pF

39) A step up transformer has a ratio of 1:10. If 100Watts of power goes into the primary coil, the power coming from the secondary coil is approximately (circle one)
- a. 1W
- b. 100W
- c. 1000W
- d. 10W

Use the circuit below for questions 40 - 47



40) Which bulb(s) will be the brightest? L7

41) Which bulb(s) will be the darkest? L6

42) Which bulbs comprise the longest series current path? L1, L4, L5

43) Which bulb(s) will draw the most current from the source? L7

44) Which bulb(s) will draw the least current from the source? L6

45) If bulb L1 burns out, what bulb(s) would stop working? L4, L5

46 If bulb L2 were to short, what bulb(s) would stop working? NONE

47) If 1A flows through bulb L2, how much current flows through bulb L3? 1A

48) A piece of iron has a resistivity of 9.71×10^{-8} ohm-meters. If its length is 1.2m and has a cross sectional area of 65cm^2, what is its resistance? $17.9 \times 10^{-6}\ \Omega = 0.0000179\ \Omega$

49) What is the electric force on two positive charges separated by a distance of 0.5mm? 9.24×10^{-22} N

50) An inductor is 1.3cm long and has 350 coils wrapped around it. The current flowing through it is measured at 0.28A. What is the magnetic field? 0.0095 T

51) Two wires sometimes touch, creating an unsafe path for current. This is called a (circle one)
- a. Short circuit
- b. Open circuit
- c. Parallel circuit
- d. Electric circuit

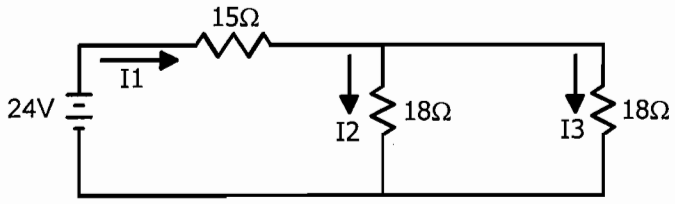
52) Conventional current (circle one)
- a. Flows from plus to minus
- b. Flows from minus to plus
- c. Cannot flow in an ionized gas
- d. Is measured in amps per second

53) The person credited with discovering that electricity can be produced from magnetism was (circle one)
- a. Hans Oersted
- b. Albert Einstein
- c. Benjamin Franklin
- d. Michael Faraday

54) What is the voltage across the resistor if a current of 0.5A flows through a 20Ω resistor? (circle one)
- a. 4V
- b. 10V
- c. 0.25V
- d. 8V

55) What is the current flowing through a 24Ω resistor connected across 240V? (circle one)
- a. 25kA
- b. 0.1A
- c. 10A
- d. 216A

56) What are the three currents, I1, I2, and I3?

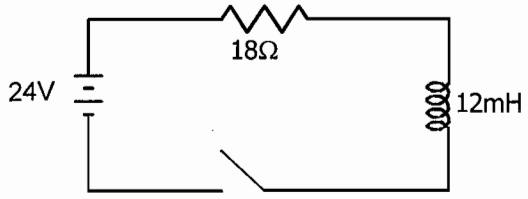


I1 = 1A

I2 = 0.5A

I3 = 0.5A

57) At time t = 0, the switch closes. How much time will it take before the inductor is fully charged?



3.33mS

58) A toroid with diameter 2.56cm, and a relative permeability of 500, has 162 turns, and 1.15A flowing through it. What is the magnetic field strength? 0.73T

STATION 1

What is the current flowing through every resistor?

I1 = 0.013-0.020A I4 = 0.012-0.018A

I2 = 0.015-0.022A I5 = 0.014-0.020A

I3 = 0.002-0.003A

STATION 2

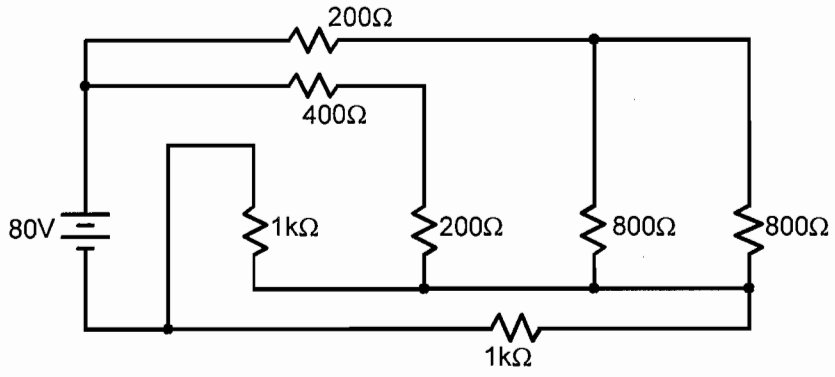
What is the power dissipated by every resistor?

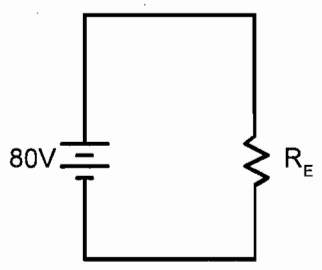
P1 = 0.08-0.11 W P4 = 0.0001-0.00011 W

P2 = 0.001-0.0014 W P5 = 0.0003-0.0004 W

P3 = 0.0007-0.0009W

TIEBREAKER: Simplify the circuit. What is the value of R_E? 800Ω





(2) $10 \| 20 + 13 = R$

$\frac{1}{10} + \frac{1}{20} = \frac{1}{R_E} \Rightarrow \frac{1}{R_E} = 0.15 \therefore R_E = 6.67\Omega$

$6.67 + 13 = 19.67\Omega$ I'LL ACCEPT 20Ω

(3) CIRCLED BULBS HAVE HIGHEST CURRENT. THREE IN PARALLEL HAVE $\frac{1}{3}$ CURRENT SO POWER DISSIPATION ($P = I^2R$) IS LESS. HIGHER POWER OUT MEANS BRIGHTER LIGHT

(10) THE THREE BULBS HAVE MAX CURRENT. IT SPLITS AND GOES THROUGH PARALLEL CIRCUIT BUT LOWER RESISTANCE CAUSES GREATER CURRENT TO FLOW THROUGH ONE BULB THAN TWO.
THEREFORE $I_3 > I_1 > I_2$

(11) TOTAL VOLTAGE DROPS MUST EQUAL 24. SINCE $V = IR$, AND I IS CONSTANT IN THIS SERIES CIRCUIT,

$$x + x + 2x + 2x + 3x + 3x = 24$$
$$12x = 24$$
$$x = 2 \quad \therefore 1\&4 = 2,\ 2\&5 = 4,\ 3\&6 = 6$$

(12) $P = VI = 24(0.78) = 19W$ (SIGNIFICANT FIGURES!)

(13) USE RHR

(19) USE RHR

(34) $\tau = RC$

$\tau = (200)(12 \times 10^{-6}) = 2.4mS$. FULLY CHARGED AT APPROX 5τ

$5(2.4mS) = 12mS$

(37) $\tau = \frac{L}{R} \Rightarrow L = \tau R$

$L = (0.243)(1.5 \times 10^3) = 365mH$

(38) $C = \frac{K\epsilon_0 A}{d} = \frac{(1.324)(8.854\times10^{-12})(12)(\frac{1}{1000})(\frac{1}{1000})}{(0.02)(\frac{1}{1000})}$

$C = 7\times10^{-12}F = 7pF$

(48) $R = \frac{\rho L}{A} = \frac{(9.71\times10^{-8})(1.2)}{65(\frac{1}{100})(\frac{1}{100})} = 17.9\times10^{-6}\,\Omega$

(49) $F = \frac{Kq_1q_2}{r^2} = \frac{(9\times10^9)(1.602\times10^{-19})(1.602\times10^{-19})}{(.0005)^2}$

$= 9.24\times10^{-22}N$

(50) $B = \frac{\mu_0 NI}{\ell} = \frac{(4\pi\times10^{-7})(350)(0.28)}{0.013}$

$= 0.0095\,T$

(56) $18||18 = 9\Omega \quad 9\Omega + 15\Omega = 24\Omega$

$I_1 = V/R = \frac{24}{24} = 1A$

$I_2 + I_3 = I_1$

$0.5 + 0.5 = 1A$

(57) $\tau = \frac{L}{R} = \frac{12\times10^{-3}}{18} = 0.00067\,S$

FULLY CHARGED AT $5\tau = 5(0.00067) = 0.0033S$

$= 3.3mS$

(58) $B = \frac{K\mu_0 NI}{2\pi r} = \frac{(500)(4\pi\times10^{-7})(16)(1.15)}{2\pi(0.0256)}$

$= 0.73\,T$

STATION 1 & 2

ONLY VOLTAGE ACROSS RESISTORS CAN BE MEASURED. SINCE ALL RESISTANCE VALUES ARE GIVEN, FOR STATION 1, CURRENTS EQUAL V/R. FOR STATION 2, $P = V^2/R$

TIEBREAKER

$800 || 800 = 400$

$(400 + 200) || (400 + 200) = 300$

$1K || 1K = 500$

$500 + 300 = 800\,\Omega$