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LAB 1 OHM'S LAW

Preparatory questions

1. What is Ohm's law? Write down the equation of Ohm's law.

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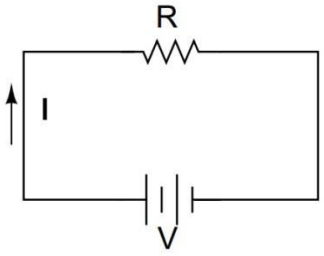
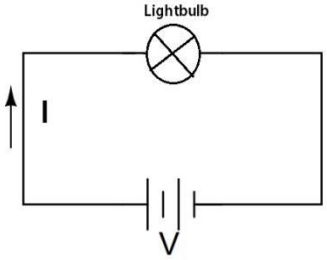
2. What is the difference between ohmic-resistor and non-ohmic resistor? Plot quantitatively the graphs of voltage *V* versus current *I* in two cases above.



Ohmic resistor



Non-ohmic resistor

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3. Calculate the resistance of a light bulb filament at 50^0C. Assume that its resistance at room temperature (20^0C) is 3Ω and the filament is made of tungsten ($\alpha = 4.5 \times 10^{-3}K^{-1}$).

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LAB 2 RESISTANCE IN CIRCUITS

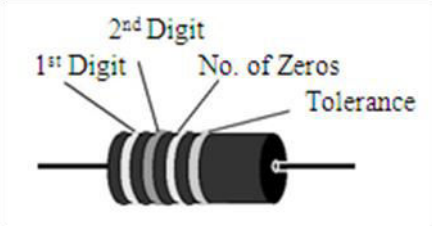
Preparatory questions

4. Using the resistor color code chart below, list the four colors (in proper order) that would be found on the following resistors:

a. 25,000 ohms ± 20%

b. 630 ohms ± 5%

c. 1,000 ohms ± 10%

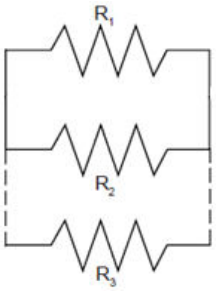


Color	Value	Multiplier		Tolerance
Black	0	10^0		
Brown	1	10^1		
Red	2	10^2		
Orange	3	10^3	None	20%
Yellow	4	10^4	Silver	10%
Green	5	10^5	Gold	5%
Blue	6	10^6	Red	2%
Violet	7	10^7		
Gray	8	10^8		
White	9	10^9		

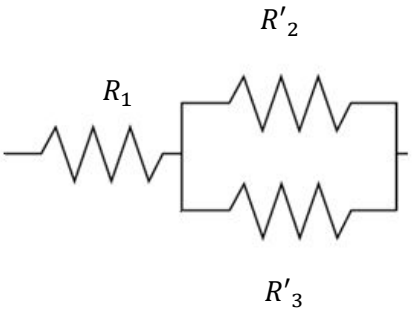
5. Calculate the resistances of the following wires whose length is 1.0 meter and diameter is 0.001 meter. Which one conducts electricity most/least effectively?
    a. Silver (resistivity $\rho = 1.62 \times 10^{-8}\Omega \cdot m$)
    b. Aluminum ($\rho = 2.75 \times 10^{-8}\Omega \cdot m$)
    c. Ion ($\rho = 9.68 \times 10^{-8}\Omega \cdot m$)

6. Write down the formula and calculate the equivalent resistance for the resistive circuits consisting of three resistors
    - In series: $R_1 = R_2 = R_3 = 10\Omega$

    - In parallel: $R_1 = R_2 = R_3 = 10\Omega$



    - In combination: $R_1 = 10\Omega, R'_2 = R'_3 = 10\Omega$



Name:

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LAB 3 LRC CIRCUIT

Preparatory questions

1. Apply a sinusoidal voltage $v = V_0 \sin(\omega t)$ (V) to following circuits:

   a. Resistive circuit

   b. Inductive circuit

   c. Capacitive circuit

   d. A series LRC circuit

   Write down the expression for the current in each case. What is the phase difference between the current and the applied voltage in each circuit above?

2. Plot quantitatively the graph of applied voltage and current as a function of time for the circuits in Question 1. On the graph for each circuit, use $V_0 = 3V$, $\omega = 100 rad/s$, $R = 10\Omega$, $C = 10\mu F$, $L = 0.02H$).

   Hint: Graphs can be plotted by hand or using software:

   - In case of using software, Microsoft Mathematics or Mathematica is a good option.

   - In case of plotting by hand, please find the identical data points.

3. A sinusoidal voltage $v = 3\sin(\omega t)(V)$ is applied to a series circuit with a resistor ($R = 10\Omega$), a capacitor ($C = 10\mu F$) and an inductor ($L = 29mH$). Calculate:

   a. The resonance frequency.

   b. The amplitude of the current at resonance.

   c. The amplitude of the voltage across the inductor at the resonant frequency.

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LAB 4 KIRCHHOFF'S LAWS

Preparatory questions

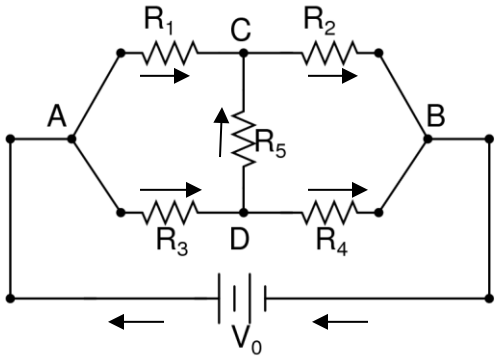

Figure: Resistive Circuit

1. What is Kirchhoff's current law? Apply Kirchhoff's current law for the above circuit at junctions A, B, C, D.

2. What is Kirchhoff's voltage law? How many loops are there in the above circuit? Apply Kirchhoff's voltage law for those loops.

3. Assume that $V_0 = 1.5\,V$, $R_1 = R_2 = R_3 = R_4 = 100\Omega$, $R_5 = 200\Omega$. Find V_5. Does the value of R_5 affect to V_5? Explain.

   Hint: This is a balanced Wheatstone bridge circuit.

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Lab 5: RC Circuit

Preparatory questions

1. Derive equations for the voltage V_C across the capacitor in a RC circuit in two cases:
   a. The capacitor is charged
   b. The capacitor is discharged

2. Use the results from question 1 to plot the voltage V_C in both cases as functions of time ($t \geq 0$, use R = 100Ω, C= 300μF, and ε = 4V, the graphs should be scaled such that the properties of exponential functions are displayed).
   Hint: Graphs can be plotted by hand or using software:

   - In case of using software, Microsoft Mathematics or Mathematica is a good option.

   - In case of plotting by hand, please find the identical data points.

3. Prove that the time constant τ and the half-life $t_{1/2}$ are related by the equation:

$$t_{1/2} = \tau \ln 2$$

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Lab 6: LR Circuit

Preparatory questions

1. Using loop rule to find *the voltages across the resistor R and the inductor L* of an RL circuit powered by an emf of voltage ε in two cases:
   a. The emf is suddenly turned on
   b. The emf is suddenly removed

2. Use the results from question 1 or from lab guide to
   a. Plot the voltages as functions of time (*four functions*, use R = 10Ω, L = 8.2mH, ε = 3V, and $t \geq 0$)
   b. From the graphs, briefly describe (in words) how those voltages change as the power is suddenly switch on and off.

   Hint: Graphs can be plotted by hand or using software:

   - In case of using software, Microsoft Mathematics or Mathematica is a good option.

   - In case of plotting by hand, please find the identical data points.

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Lab 7: Magnetic Fields of Coils

Preparatory questions

1. From Biot-Savart law, derive the expression of the magnetic field along the perpendicular axis through the center of the coil created by a single coil:

   $$B = \frac{\mu_0 N I R^2}{2\left(x^2 + R^2\right)^{3/2}}\hat{x}$$

   Then draw the direction of the magnetic field created by the electric current.
   (read the lab guide for the meaning of all variables and parameters in the formula)

2. From the above result, find the magnetic fields of a system consisting of two parallel identical coils along the perpendicular axis through the centers of the coils.

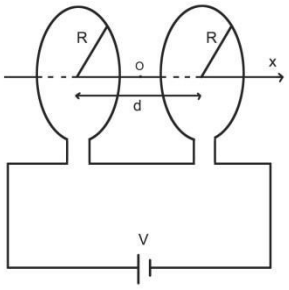

Figure 1

Then plot the magnetic field as a function of position in three cases:

a. The separation *d* equals to the coil radius *R*(*d=R=0.1050 m)*
b. The separation *d* is half of the coil radius *R* (*d=0.5R=0.0525 m)*
c. The separation *d* is 1.5 times of the coil radius *R* (*d=1.5R=0.1575 m)*

Simplify the results of the magnetic fields with boundary conditions: (i) the coil separation d is equal to the radius of the coil R, this gives a uniform magnetic field between the coils and (ii) the magnetic fields calculated are very close to the center of the coils (x=0).

3. Derive the expression of the magnetic fields inside an ideal solenoid of N turns and length L.

$$B = \frac{\mu_0 NI}{L}$$

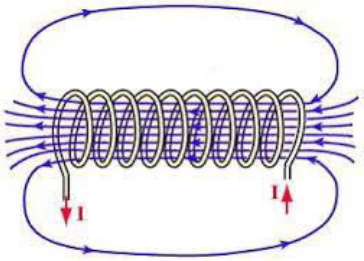

Figure 2: Solenoid

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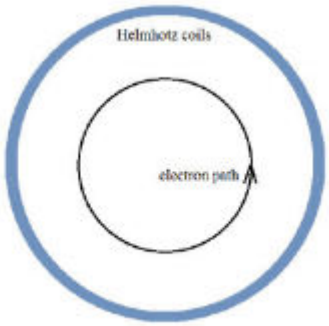
Lab 8: The e/m_e ratio experiment

Preparatory questions

1. When is a uniform magnetic fields created by two circular coils of wire? Write down the expression of the uniform magnetic field on the middle of the Helmholtz coils?

2. The below figure shows the circular path of electron which move counter-clockwise in uniform magnetic fields generated by the Helmholtz coils. The coils have electric currents flowing through the wires of the coils. Draw the direction of the electric currents and the magnetic fields in the figure. Explain.



3. Derive the expression of the electron's charge to mass ratio:

$$\frac{e}{m_e} = \frac{125R^2V}{32\mu_0^2N^2I^2r^2}$$

(read the lab guide for the meaning of all the parameters and variables in the formula)