X2.4a

115

PHYS-115(4) (Kaldon-26364) **Name** S O L U T I O N
WMU - Spring 2005
Exam 2A - 100,000 points **Book Title** ____________________

Rev. 02/23/05 We.A4

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Short Answers Should Be Short! – Feel Free to Ask Any Questions

EXAM 2 [FORM - A]

PHYS-115 (KALDON-4)

SPRING 2005

WMU

Oersted, Hans Christian (ör′stĭð), 1777–1851, Danish physicist and chemist.

His discovery that a magnetic needle is deflected by a conductor carrying an electric current showed a relation between ELECTRICITY and MAGNETISM and initiated the study of electromagnetism. (One of the) unit(s) of magnetic field strength, the oersted, is named for him. Oersted was the first to isolate ALUMINUM.

Energy, 1819

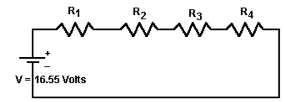
Danish physicist Hans Christian Oersted, 42, advances knowledge of electromagnetic energy. He notices that a compass needle located close to a wire carrying an electric current will swing wildly but will finally settle at right angles to the wire. He suspects that the current in the wire must set up a magnetic field around it, and his observation will be the starting point for others (see ROMAGNOSI, 1802; AMPÈRE, 1820; FARADAY, 1821; ELECTROMAGNET, 1823).

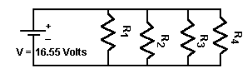
Microsoft Bookshelf '95

$$\mu_0 = 4\pi \times 10^{-7}\, T \cdot m / A$$

This is the Story of Four Resistors Living in the Big City… Circuit City… (50,000 points)

1.) Consider four identical 625 Ω resistors and a 16.55 volt battery. Find (a) the maximum and (b) the minimum equivalent resistance you can make with these resistors. Be sure to draw the circuit diagrams for full credit.





(a) Maximum = Series

$$R_{eq} = R_1 + R_2 + R_3 + R_4 = 4R = 4(625\Omega) = 2500.\Omega$$

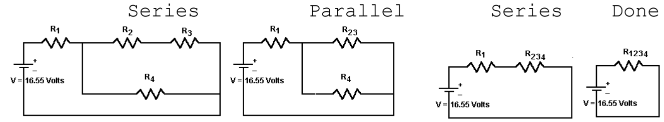
(b) Minimum = Parallel

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} = \frac{4}{R}$$

$$R_{eq} = \frac{R}{4} = \frac{625\Omega}{4} = 156.3\Omega$$

(c) Our four identical 625 Ω resistors and our 16.55 volt battery are hooked up in the circuit as shown. Find the equivalent resistance of the circuit, R_{1234} , by reducing the resistor network.

Series Parallel Series Done!

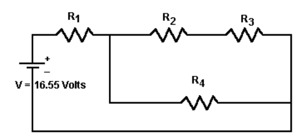


$$R_{23} = R_2 + R_3 = 2(625\Omega) = 1250.\Omega$$

$$\frac{1}{R_{234}} = \frac{1}{R_{23}} + \frac{1}{R_4} = \frac{1}{1250.\Omega} + \frac{1}{625\Omega}$$

$$R_{234} = 416.7\Omega$$

$$R_{1234} = R_1 + R_{234} = 625\Omega + 416.7\Omega = 1042\Omega$$



(d) Find the current, I_{total} , and the power dissipated, P_{total} , of the equivalent circuit. *If you did not get an answer to (c), use $R_{eq} = 1625\ \Omega$.*

$$V = IR$$

$$I = \frac{V}{R} = \frac{16.55 volts}{1042\Omega} = 0.01588A$$

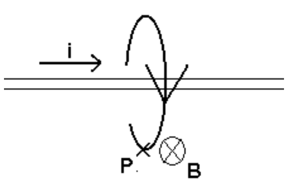
$$P = IV = (0.01588A)(16.55volts) = 0.2628W$$

(e) An RC circuit consists of a 625 Ω resistor and a 625 μF capacitor. Find the time t in seconds it takes for the fully charged capacitor to discharge to half its initial value, i.e. $q = 0.500\ Q_{max}$.

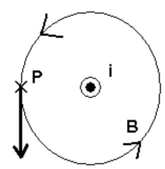
$$\tau = RC = (625\Omega)(625\times10^{-6}F) = 0.3906\sec$$
$$q = Qe^{-t/RC}\ ;\ \ q = 0.500Q$$
$$0.500Q = Qe^{-t/RC}$$
$$0.500 = e^{-t/RC}$$
$$\ln\left(e^{-t/RC}\right) = \ln(0.500)$$
$$\frac{-t}{RC} = -0.6931$$
$$t = (0.6931)RC = (0.6931)(0.3906\sec)$$
$$= 0.2707\sec$$

Wait A Second! How'd Oersted Do It? SEE COVER SHEET **(50,000 points)**

2.) *Yesterday afternoon, after PHYS-115 class, after my 4pm appointment, after the rest of the Physics Dept. meeting, one of my colleagues came in and showed me a problem in a Physics Education book and he didn't understand how they could get the answer they did. I looked at it, at first agreed with him, and then realized that Real Life isn't as simple as we make it in class sometimes. Consider: Oersted runs a current through a wire and a compass needle changes its direction. The North end of a compass needle points in the same direction as a magnetic field points (N points towards S).* (a) A current carrying wire is shown below, in two views. Show by R.H.R. which way the magnetic field from the wire points at the P in both views.

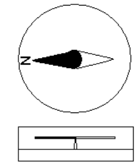


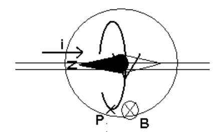
View From Above

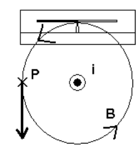


View Looking From Right Side

(b) *A compass needle points to the LEFT while you are sitting in 1104 Rood Hall. But from part (a), there's no way that the B-field from the wire could deflect the needle at point P. But… a real compass is thick. The needle would sit ABOVE the wire – and there WOULD be a magnetic field. Okay, okay. Enough of Dr. Phil marveling at the wonder of Physics…* Suppose the compass sits directly ON TOP of the wire. For a wire carrying a current of 1.00 A, find the distance d where the magnetic field measures $B = 0.000100\ T$. (This is 1/10,000th of a Tesla or 1.00 Gauss, the same strength as the Earth's magnetic field here on the surface.)





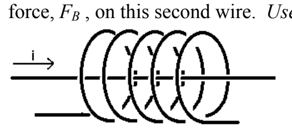


$$B = \frac{\mu_0 I}{2\pi r} = \frac{\mu_0 I}{2\pi d}$$
$$d = \frac{\mu_0 I}{2\pi B} = \frac{(4\pi\times10^{-7}\,T\cdot m/A)(1.00A)}{2\pi(0.000100T)}$$
$$= 0.002000m\ \ (= 2.000mm)$$

(c) A coil consists of 10,500 turns of wire in a length of 15.0 cm and a diameter of 8.00 cm. The B-field in the solenoid measures $B = 0.00135\ T$, as shown. Find the magnitude of the current I in the coil and indicate whether the current comes out the LEFT or the RIGHT of the coil.

$$B = \frac{\mu_0 NI}{\ell}$$
$$I = \frac{B\ell}{\mu_0 N} = \frac{(0.00135T)(0.150m)}{(4\pi\times10^{-7}\,T\cdot m/A)(10{,}500)}$$
$$= 0.01535A$$

(d) For the same solenoid coil as in (c), with $B = 0.00135\ T$, a second wire is inserted down the center of the coil. If the current in this second wire is $i = 0.500\ A$ as shown, find the magnitude and direction of the magnetic force, F_B , on this second wire. *Use the length of the coil as the length of the second wire.*



$\vec{B}$ and i are anti-parallel
$\therefore\ \vec{F}_B = 0$

(Alternately, the second current, i_2 , is everywhere in the coil perpendicular to the first current, i_1 , and therefore there is no magnetic force between perpendicular wires.)

(e) The E-field part of a velocity selector consists of two parallel plates, separated by a gap $d = 0.100\ m$ and with a potential difference $\Delta V = 1500.\ volts$. If the B-field part uses the same solenoid coil with $B = 0.00135\ T$ as above, find the "design speed" v for this velocity selector, using any charged particle.

$$\Delta V = Ed$$
$$E = \frac{\Delta V}{d} = \frac{1500.volts}{0.100m} = 15{,}000V/m$$
$$v = \frac{E}{B} = \frac{15{,}000V/m}{0.00135T} = 1.111\times10^{7}\,m/s = 11{,}110{,}000m/s$$