PHYSICS 231 – TEST # 2

NAME:

STUDENT ID #:

USEFUL CONSTANTS

$$\epsilon_0 = 8.85 \times 10^{-12} C^2/(N \cdot m^2)$$

$$k = \frac{1}{4\pi\epsilon_0} = 8.988 \times 10^9 \ N \cdot m^2/C^2$$

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

$$m_e = 9.1 \times 10^{-31} kg$$

USEFUL FORMULAS

Capacitance: $C = Q/V$
Parallel-plate capacitor: $C = \epsilon_0 A/d$
Capacitors in series:

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

Capacitors in parallel:

$$C_{eq} = C_1 + C_2$$

Energy:

$$U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

Energy density:

$$u = \frac{1}{2}\epsilon_0 E^2$$

Capacitor filled with dielectric: $C = KC_0$
Energy density in dielectric:

$$u = \frac{1}{2}\epsilon E^2 \ , \quad \epsilon = K\epsilon_0$$

Current and current density:

$$I = \frac{dQ}{dt} = n|q|v_d A \ , \qquad \vec{J} = nq\vec{v}_d$$

Resistivity: $\rho = E/J$
Variation with temperature:

$$\rho(T) = \rho_0[1 + \alpha(T - T_0)]$$

Ohm's law: $V = IR \ , \qquad R = \rho L/A$
Power into a resistor: $P = VI = I^2R = V^2/R$
Resistors in series:

$$R_{eq} = R_1 + R_2$$

Resistors in parallel:

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$$

Kirchhoff's rules: $\sum I = 0 \ , \qquad \sum V = 0$
Capacitor charging:

$$Q = C\mathcal{E}\left(1 - e^{-\frac{t}{RC}}\right) \ , \qquad I = \frac{dQ}{dt} = \frac{\mathcal{E}}{R}\, e^{-\frac{t}{RC}}$$

Capacitor discharging:

$$Q = Q_0 e^{-\frac{t}{RC}} \ , \qquad I = \frac{dQ}{dt} = -\frac{Q_0}{RC}\, e^{-\frac{t}{RC}}$$

There are three (3) problems in this test. Make sure you answer all questions in each problem for full credit. Show as much of your work as possible to receive partial credit, in case you don't come up with the right answer. Good luck!

George Siopsis - 3/7/06

Problem 1

(a) A solid slab of metal is placed between the plates of a capacitor without touching either plate. Does the capacitance increase, decrease, or stay the same? Explain.

(b) A rule of thumb used to determine the internal resistance of a battery is that it is the open-circuit voltage divided by the short-circuit current. Is this correct? Explain.

(c) Resistors R_1 and R_2 are connected in parallel to a battery of negligible internal resistance. What happens to the current through R_1 when R_2 is removed from the circuit? Explain.

Problem 2

An isolated parallel-plate capacitor has a charge of $Q = 1.4\ \mu C$. Each plate is a square of side $a = 1.5$ m. The separation between the plates is $d = 1.2$ mm.

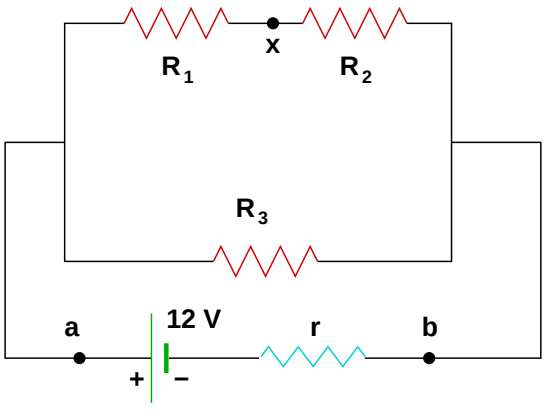
(a) Calculate the capacitance.

(b) What is the voltage between the plates and the electric field inside the capacitor?

(c) How much energy is stored in the capacitor?

(d) How much work do you have to do to increase the separation between the plates to 3.6 mm? Assume that the charge on the plates remains constant.

Problem 3



A 12-V battery of internal resistance $r = 1\ \Omega$ is connected to resistors $R_1 = 2\ \Omega$, $R_2 = 4\ \Omega$ and $R_3 = 12\ \Omega$ as shown.

(a) Find the current through each of the three resistors.

(b) What is the terminal voltage V_{ab} of the battery?

(c) If the wire is cut at point x, what will be the current through each of the three resistors?