

**Instructions: You have a total of 50 minutes to complete this test.**

**Answer each question completely showing complete details.**

**For complete credit you must include correct SI units with numerical answers.**

Time Start \_\_\_\_\_ Time finish \_\_\_\_\_ pledged \_\_\_\_\_

Constants:  $k = 8.987 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2}$ ;  $\epsilon_0 = 8.854 \times 10^{-12} \frac{\text{C}^2}{\text{Nm}^2}$ ;  $\mu_0 = 4\pi \times 10^{-7} \frac{\text{Tm}}{\text{A}}$ ;  $\mu = 1 \times 10^{-6}$

[1] A wire has a length  $L = 5$  m and is carrying a current towards the  $+x$  direction of 7 A.

(a) Calculate the magnitude of the magnetic field at a distance of 0.1 m from the wire.

(b) Suppose that the same wire, with the same current is subjected to an external magnetic field in the  $-y$  direction of strength  $B = 0.1$  T. Calculate the total vector force on the wire (do not forget the direction;  $\hat{x}$ ,  $\hat{y}$ , or  $\hat{z}$  ).

(c) In a region of space, it is observed that the electric potential varies as:  $V = ax + b$  . Calculate the vector electric field in this region of space.

**[2]** A parallel plate capacitor has plates of area  $A$  and separation  $d$ . On the plate located at the  $x=0$ , a surface charge density  $+\sigma$  exists while on the plate located at  $x=d$ , a surface charge density  $-\sigma$  exists. Answer the following assuming that this can be regarded as an ideal capacitor.

**(a)** Starting from Gauss's Law, show (showing complete details) how to calculate the vector electric field within the capacitor in terms of  $\sigma$ ,  $\epsilon_0$  and  $\hat{x}$ .

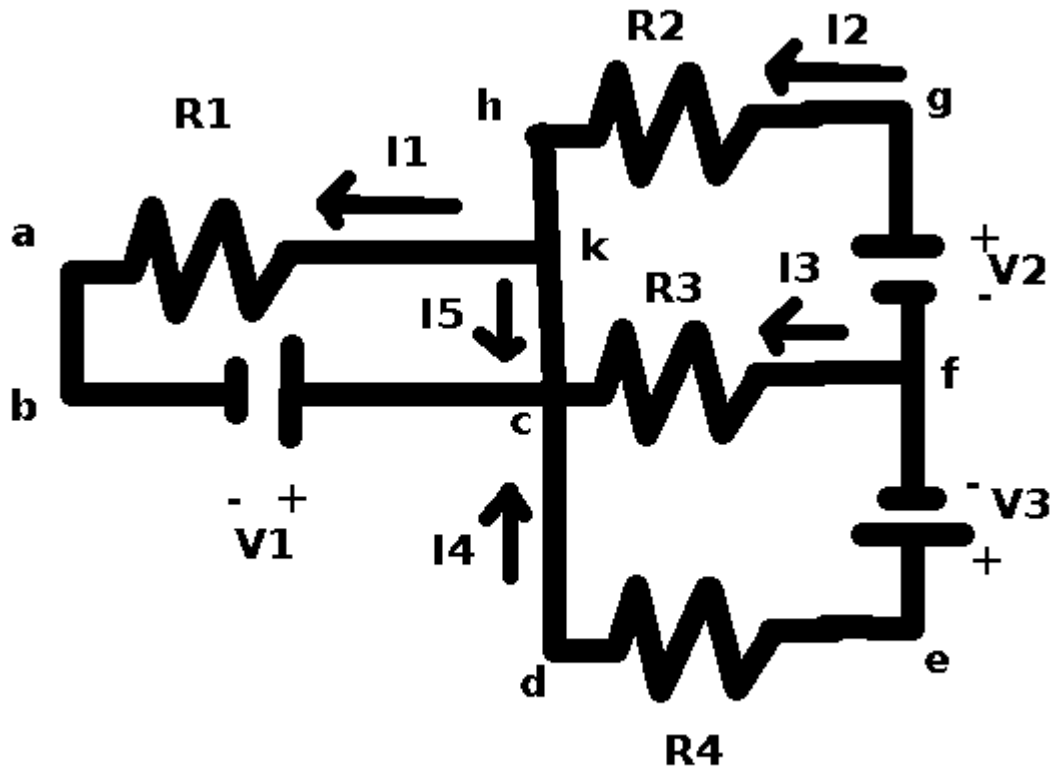
**(b)** Calculate the **magnitude** of the potential difference between the two plates in terms of  $\sigma$ ,  $\epsilon_0$  and  $d$ .

**(c)** Calculate the capacitance of the capacitor in terms of  $\epsilon_0$ ,  $A$  and  $d$ .

**(d)** Calculate the total energy stored on the capacitor in terms of  $C$  and  $V$ .

**(e)** Calculate the energy density in terms of  $\epsilon_0$  and  $E$ .

**(f)** Suppose a capacitor ( $C=1\mu\text{f}$ ) has potential difference of  $100\text{V}$ . Find the total stored electrostatic energy with correct SI units.



**[3]** Consider the circuit shown above. Write the Kirchoff's laws equations that result from the following:

Loop (abcka) \_\_\_\_\_

Loop (cdefc): \_\_\_\_\_

Loop (cfghkc): \_\_\_\_\_

@c: \_\_\_\_\_

@f: \_\_\_\_\_

Suppose with the following values:

$V_1=10V : V_2=20V : V_3=30V : R_1=1\Omega : R_2=2\Omega : R_3=3\Omega : R_4=4\Omega$ , the following currents resulted:  $I_1=10A, I_2=1.92A, I_3=-5.38A, I_4=3.46A$ , and  $I_5=-8.08 A$ .

Calculate the total power radiated with correct SI units.

$P=$  \_\_\_\_\_

What is the interpretation of the value provided for current  $I_5$ ?

**[4]** A capacitor has a plate area of  $.5 \text{ m}^2$  and a plate separation of  $0.1 \text{ m}$ .

**(a)** Calculate the capacitance of this capacitor.

**(b)** If  $C_1$  has a capacitance of  $1 \mu\text{f}$  and  $C_2$  has a capacitance of  $5 \mu\text{f}$ , calculate the capacitance of the two capacitors when they are connected in series.

**(c)** If  $C_1$  has a capacitance of  $1 \mu\text{f}$  and  $C_2$  has a capacitance of  $5 \mu\text{f}$ , calculate the capacitance of the two capacitors when they are connected in parallel.

A has a resistivity of  $20 \Omega\text{m}$ . A resistor from this material is  $0.1 \text{ m}$  long and has a cross sectional area of  $0.1 \text{ m}^2$ .

**(d)** Calculate the resistance of this resistor.

**(e)** If  $R_1$  has a resistance of  $100 \Omega$  and resistor  $R_2$  has a resistance of  $50 \Omega$ , calculate the resistance of the two resistors when connected in series.

**(f)** If  $R_1$  has a resistance of  $100 \Omega$  and resistor  $R_2$  has a resistance of  $50 \Omega$ , calculate the resistance of the two resistors when connected in parallel.

**(g)** Calculate the RC time constant when a resistor ( $R=1 \times 10^5 \Omega$ ) is connected in series with a capacitor ( $C=3 \mu\text{f}$ ).