

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

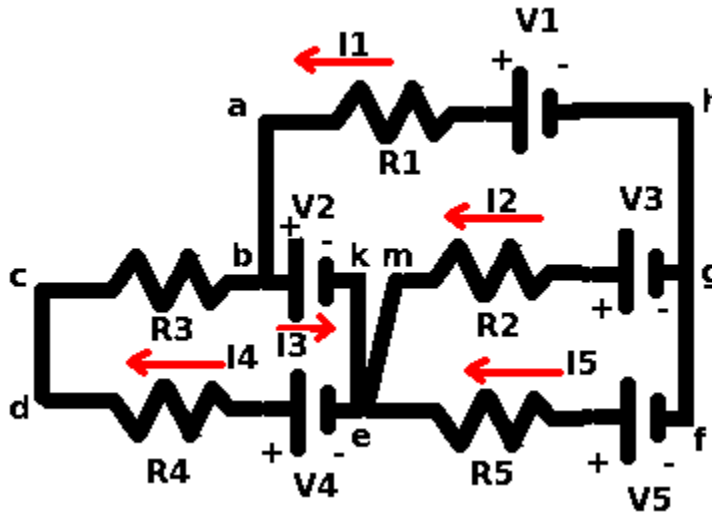
**Answer each question completely showing complete details.**

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

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

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

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



loop (abkemgha):

loop (cdekbc):

loop (mefgm):

@g:

@e:

If the components have the following values:

$R_1=1\Omega$ ,  $R_2=2\Omega$ ,  $R_3=3\Omega$ ,  $R_4=4\Omega$  and  $R_5=5\Omega$

$V_1=10\text{V}$ ,  $V_2=20\text{V}$ ,  $V_3=30\text{V}$ ,  $V_4=40\text{V}$  and  $V_5=50\text{V}$

The following currents result:

$I_1=106.7 \text{ A}$ ,  $I_2=73.3 \text{ A}$ ,  $I_3=-103.9 \text{ A}$ ,  $I_4=2.9 \text{ A}$ ,  $I_5=33.3\text{A}$

Calculate the power radiated by resistor R3.

What is the interpretation of the value provided for current I3?

**[2]** A capacitor has a plate area of  $.25 \text{ m}^2$  and a plate separation of  $0.1 \text{ m}$ .

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

**(b)** If  $C_1$  has a capacitance of  $3 \mu\text{f}$  and  $C_2$  has a capacitance of  $6 \mu\text{f}$ , calculate the capacitance of the two capacitors when they are connected in series.

**(c)** If  $C_1$  has a capacitance of  $3 \mu\text{f}$  and  $C_2$  has a capacitance of  $6 \mu\text{f}$ , calculate the capacitance of the two capacitors when they are connected in parallel.

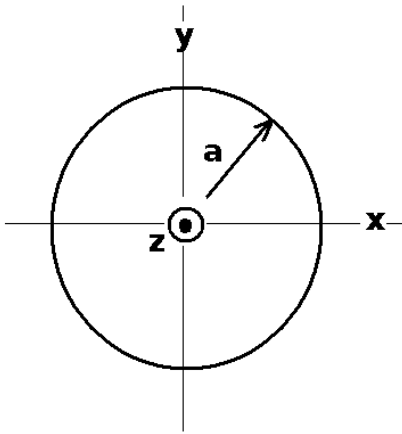
A material has a resistivity of  $30 \Omega\text{m}$ . A resistor from this material in the shape of a cylinder is  $0.1 \text{ m}$  long and has a cross sectional area of  $0.1 \text{ m}^2$ .

**(d)** Calculate the resistance of this resistor measured across the ends.

**(e)** If  $R_1$  has a resistance of  $30 \Omega$  and resistor  $R_2$  has a resistance of  $60 \Omega$ , calculate the resistance of the two resistors when connected in series.

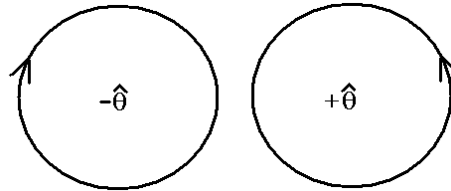
**(f)** If  $R_1$  has a resistance of  $30 \Omega$  and resistor  $R_2$  has a resistance of  $60 \Omega$ , calculate the resistance of the two resistors when connected in parallel.

**(g)** Calculate the RC time constant when a resistor ( $R=3 \times 10^5 \Omega$ ) is connected in series with a capacitor ( $C=6 \mu\text{f}$ ).



**[3]** A wire of radius  $a$  carries a uniform current density given by  $\mathbf{j}$  which is directed out of the page as shown. The wire carries a total current  $I$ .

(a) Which direction does the magnetic field circulate around the wire? (circle the correct answer below).



(b) Calculate the magnitude of the current density in terms of  $I$  and  $a$ .

(c) Showing complete details, including sketches as necessary, calculate the vector magnetic field inside the wire in terms of  $I$ ,  $a$  and the radius vector  $r$ .

(d) Showing complete details, including sketches as necessary, calculate the vector magnetic field outside the wire in terms of  $I$ , and the radius vector  $r$ .

(e) Suppose  $I=100$  A and  $a=0.1$ m. Find the magnitude of the magnetic field at the surface of the wire with correct SI units.

**[4]** A parallel plate capacitor has plates of area  $A$  separated by a distance  $d$ . One plate is in the  $x$ - $y$  plane at  $z=0$  and the other plate is in the  $x$ - $y$  plane at  $z=d$ .

(a) Allow  $d$  to be equal to  $1\text{m}$ . If the potential between the plates varies as  $V=10 - 10z$ , find the potential difference defined by  $\Delta V=V(z=d)-V(z=0)$  between the plates. Be sure to include correct SI units here.

(b) Find the electric field between the plates defined by  $\vec{E}=-\frac{\Delta V}{\Delta z}\hat{z}$ , noting that  $\Delta z=d$ . Be sure to use correct SI units.

(c) Find the surface charge density defined by  $E=\frac{\sigma}{\epsilon_0}$ . Be sure to use correct SI units.

(d) Find the energy density in the capacitor, using correct SI units.