Instructions: You have a total of 55 minutes to complete this test.
Answer each of the following questions completely.

Time Start_______________ Time finish_____________ Pledged________________________

You must supply all details that led to your answer and correct SI units where required.

Do not discuss any aspect of this test with anyone until I return the test.

Although you may use additional sheets of paper which should be turned in with your test, please write (neatly) your answers on the pages where the problems are presented.

Constants: $e^- = -1.602\text{x}10^{-19}\text{C}$, $k = 8.99\times10^9\ \frac{\text{Nm}^2}{\text{C}^2}$, $\varepsilon_0 = \frac{1}{4\pi k} = 8.85\text{x}10^{-12}\ \frac{\text{C}^2}{\text{Nm}^2}$

[1] A wire shaped as an infinite cylinder of radius a has a current I uniformly spread across its cross sectional area.
(a) Calculate the magnitude of the current density inside the inner wire assuming the current flows along the axis. Your answer will involve I, and a. **Be sure to show details and sketches.**

(b) Calculate the magnetic field inside the wire at a distance s (s<a). Your answer will involve J, and s.

(c) Find the magnetic field at a distance s outside the wire. Your answer will involve I and s.

(d) If I=1 A and a=.01 m, provide a numerical value for B at the surface of the wire.

[2] A parallel plate capacitor has plates of area A and separation d. On the plate located at the origin, a surface charge density $+\sigma$ exists while on the plate located at d a surface charge density $-\sigma$ exists. Answer the following assuming that this can be regarded as an ideal capacitor. **Note: you must show all details (including sketches) for complete credit. Just writing answers is not enough for full credit here.**

(a) Starting from Gauss's Law, show how to calculate the **vector** electric field within the capacitor in terms of $\sigma, \varepsilon_0 \text{ and } \hat{x}$.

(b) Calculate the **magnitude** of the potential difference between the two plates in terms of $\sigma, \varepsilon_0 \text{ and } d$.

(c) Calculate the capacitance of the capacitor in terms of $\varepsilon_0, A, \text{and } d$.

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

(e) Calculate the energy density in terms of ε_0 and E.

(f) Suppose the capacitor plates have a potential difference of 100V and the plates are separated by d=0.1 m. Provide a numerical answer for the energy density together with correct SI units.

(e) Now suppose that in some region of space the electric potential is given by: $V = c - ax$ where a and c are constants. What is the **vector** electric field in this region of space?

[3] A rod had a cross sectional area $A = 4x10^{-2}m^2$ and it is 3.0 m long. The material which the rod is made of has a resistivity given by $\rho_R = 2x10^{-7}\,\Omega m$.
(a) Calculate the resistance of the rod.

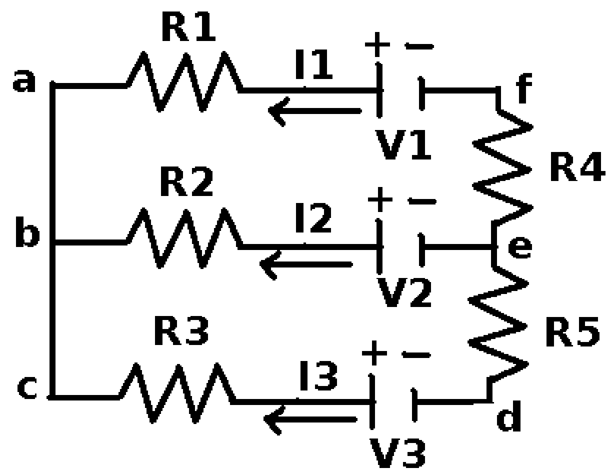
(b) If two rods each with 2.7 Ω resistance are connected in parallel, calculate the equivalent resistance.

(c) If two rods each with 2.7 Ω resistance are connected in series, calculate the equivalent resistance.

A material having a dielectric constant $\kappa = 7.5$ is inserted completely inside a capacitor. The capacitance is measured to be 100μf with the material inside.
(d) What is the geometrical capacitance of the system together with correct SI units?

(e) If two capacitors each with a capacitance of 15μf are connected in parallel, calculate the equivalent capacitance.

(f) If two capacitors each with a capacitance of 15μf are connected in series, calculate the equivalent capacitance.



[4] Consider the circuit shown above.
(a) Write down Kirchoff's loop equations for the following two loops:
(abefa): ________________________
(bcdeb): ______________________

(b) Write down Kirchoff's junction equations for the following junction:
@b: _________________________

Suppose that you have the following values for voltages and resistances:
V1=10V: V2=20V: V3=30V: R1=1Ω:R2=2Ω:R3=3Ω:R4=4Ω:R5=5Ω.
If the solution for the currents are:I1=-1.82A:I2=0.45 A:I3=1.36 A, then:

(c) Calculate the total power dissipated in the circuit together with correct SI units.

(d) What is the interpretation of the current provided for I1?