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Don't forget to write your name, your I.D. # and your section on your booklet.

1) 10 marks

A certain charge  $Q$  is to be divided into two parts ( $Q-q$ ) and  $q$ . What is the relation of  $Q$  to  $q$  if the two parts, placed a given distance apart, are to have a maximum Coulomb repulsion?

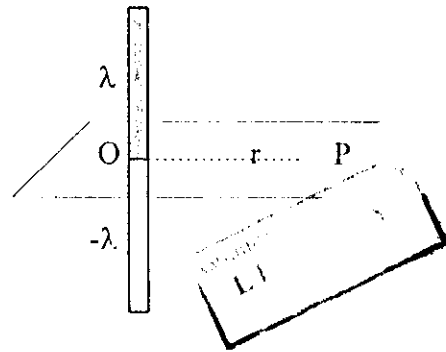


2) 10 marks

A neutron is thought to be composed of one "up" quark of charge  $+\frac{2}{3}e$  and two "down" quarks each having charge  $-\frac{e}{3}$ . If the down quarks are  $2.6 \text{ F}$  apart inside the neutron, what is the repulsive electrical force between them? ( $1 \text{ F} = \text{Fermi} = 10^{-15} \text{ m}$ )

3) 15 marks

A charge per unit length of  $\lambda$  is uniformly distributed along the upper half of an infinite insulating rod and a charge per unit length of  $-\lambda$  is uniformly distributed along the lower half, as shown in the figure. Find the electric field  $\vec{E}$  at  $P$  situated at a distance  $r$  from the point  $O$ .



4) 15 marks

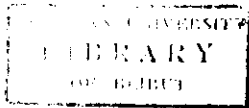
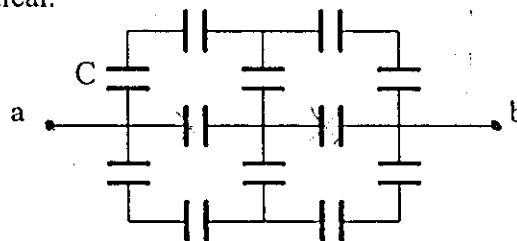
The spherical region  $a < r < b$  carries a charge per unit volume of  $\rho = A/r$ , where  $A$  is a constant. At the center ( $r = 0$ ) of the enclosed cavity is a point charge  $q$ . What should be the value of  $A$  so that the electric field in the region  $a < r < b$  has constant magnitude?

5) 15 marks

Knowing that the potential in the space is given by  $V(x,y,z) = \xi(x^2 + y^2)$  Where  $\xi$  is a constant. Find the electric field  $\vec{E}$  and sketch the line fields in the space.

6) 10 marks

Find the equivalent capacitance between  $a$  and  $b$  of the circuit shown where all the capacitors are identical.



7) 10 marks

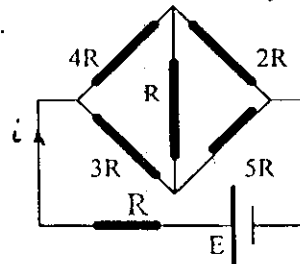
Show that the plates of a parallel-plate capacitor attract each other with a force given by  $F = \frac{q^2}{2\epsilon_0 A}$ . Where  $q$  is the charge and  $A$  is the area of the plate.

8) 10 marks

When 115 V is applied across a 9.66 m long wire, the current density is  $1.42 \text{ A/m}^2$ . Calculate the conductivity of the wire material.

9) 15 marks

Calculate the current  $i$  if  $E = 12 \text{ V}$  and  $R = 3\Omega$ . (Hint, use  $\Delta \leftrightarrow Y$  transformation).

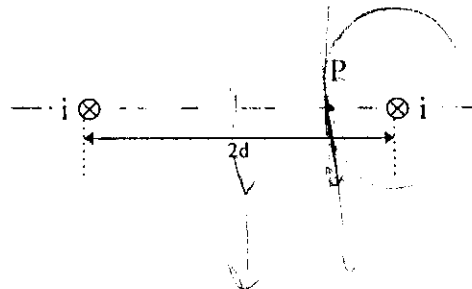


10) 15 marks

A long, rigid conductor, lying along the  $x$  axis, carries a current of 5.0 A in the  $(-x)$  direction. A magnetic field  $\vec{B}$  is present, given by  $\vec{B} = 3\hat{x} + 8x^2\hat{y}$ , with  $x$  in meters and  $\vec{B}$  in mT. Calculate the force on the 2.0 m segment of the conductor that lies between  $x = 1.2 \text{ m}$  and  $x = 3.2 \text{ m}$ .

11) 15 marks

Two long parallel wires a distance  $2d$  apart carry equal currents  $i$  in the same direction, into the plane of the figure. Derive an expression for the magnetic field  $B$  at a point  $P$  on the line connecting the wires and a distance  $x$  from the point midway between them. Plot  $B$  against  $x$ .

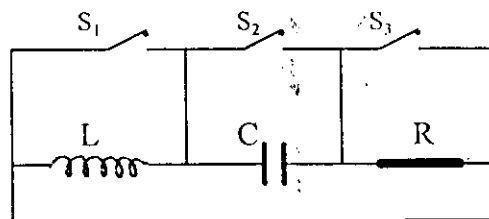


12) 15 marks

- Find an expression for the energy density as a function of the radial distance  $r$  for a toroid of rectangular cross section.
- Integrating the energy density over the volume of the toroid, calculate the total energy stored in the field of the toroid.

13) 15 marks

Consider the circuit shown:



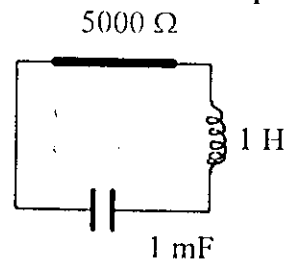
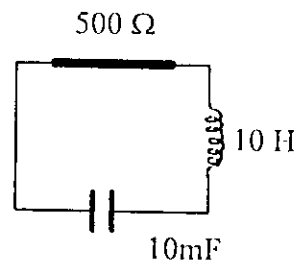
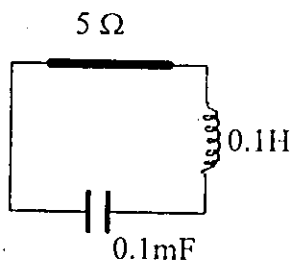
Describe qualitatively and quantitatively what happens if one of the switches is closed and the other two switches are open, starting with switch  $S_1$  closed, then  $S_2$  and  $S_3$ ?

14) 15 marks

In an LC circuit with  $L = 52.2 \text{ mH}$  and  $C = 4.21 \mu\text{F}$ , the current is initially a maximum. How long will it take before the capacitor is fully charged for the first time?

15) 15 marks

Which one of the following circuits resonate? What is its resonance frequency?



Good Luck

