

October 31, 2007

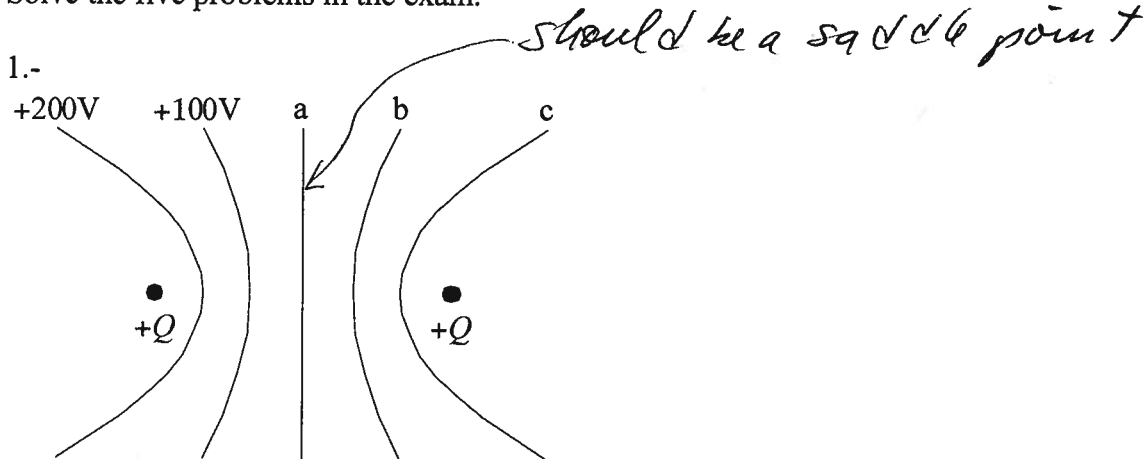
Physics 272 Exam 2:

Name: Solution

The value of the electric constant $\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$.

The value of the magnetic constant $\mu_0 = 4\pi \times 10^{-7} \text{ T m/A}^2$

Solve the five problems in the exam.



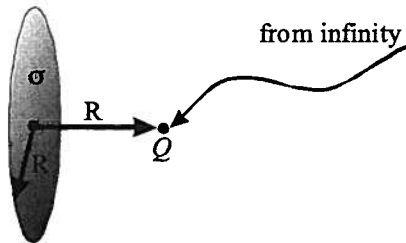
Two equal positive charges are placed x meters apart. The equipotential lines are at 100 Volt intervals.

What would be the potential for line a ? 0

What would be the potential for line c ? +200

What would be the work required to move a third charge with charge $q = -1.6 \times 10^{-19} \text{ C}$ from the $+100 \text{ V}$ line to line b ? 0

2.- Calculate the work done to bring a charge Q from infinity to a place at a distance R along the axis of a uniformly charged disk with surface charge density and radius R .



- a) Find an approximate solution assuming that the charge is concentrated at the center of the disk.
 b) Find the exact solution.

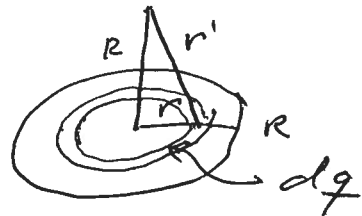
a) Total charge $Q_{\text{disk}} = \sigma \pi R^2$ $V = \frac{\sigma \pi R^2}{4\pi \epsilon_0 R}$

Work = $QV = \frac{Q Q_{\text{disk}}}{4\pi \epsilon_0 R} = \boxed{\frac{Q \sigma R}{4\epsilon_0}}$ $k Q \sigma \pi R$

b) Potential at R

$$dV = \frac{1}{4\pi \epsilon_0} \frac{dq}{r'}$$

$$dq = 2\pi r \sigma \cdot dr$$



$$\frac{1}{r'} = \frac{1}{\sqrt{R^2 + r^2}}$$

$$V = \frac{\pi \sigma}{4\pi \epsilon_0} \int_0^R \frac{2r \, dr}{\sqrt{R^2 + r^2}} = \frac{2\pi \sigma}{4\pi \epsilon_0} \sqrt{R^2 + r^2} \Big|_0^R$$

$$V = \frac{1}{2} \frac{\sigma R}{\epsilon_0} \sqrt{2} - \frac{1}{2} \frac{\sigma R}{\epsilon_0}$$

$$W = QV = \frac{Q \sigma R}{2\epsilon_0} (\sqrt{2} - 1)$$

$$2\pi Q k \sigma R (\sqrt{2} - 1)$$

3.- A parallel plate capacitor (large enough to neglect edge effects) has a plate spacing of 1.5 mm, which is filled with a dielectric of $\kappa = 4.3$, and its capacitance is $80 \mu\text{F}$. If the dielectric is taken out and the plate spacing is doubled, then what is the new capacitance?

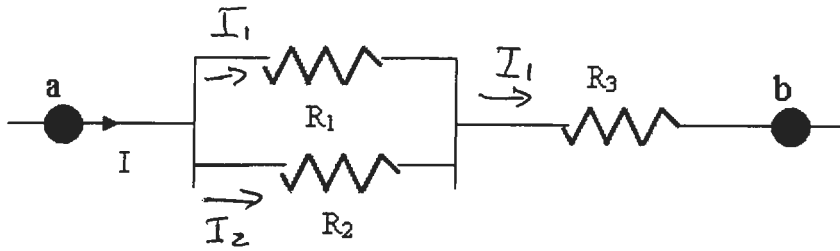
$$C = \epsilon_0 \kappa \frac{A}{d}$$

$$80 \times 10^{-6} = 8.86 \times 10^{-12} \times 4.3 \times \frac{A}{1.5 \times 10^{-3}}$$

$$C_{\text{new}} = \frac{C_{\text{old}}}{\kappa \cdot 2}$$

$$C_{\text{new}} = \frac{80 \times 10^{-6}}{4.3 \cdot 2} = \underline{9.3 \mu\text{F}}$$

4.-



In the diagram above, the voltage difference between a and b is 6V. If $R_1 = 25 \Omega$, $R_3 = 45 \Omega$, and $I = 0.095 \text{ A}$, find R_2 and the power dissipated on this resistor.

$$V_{ab} = I R_{eq} \quad R_{eq} = \frac{R_2 \cdot 25}{25 + R_2} + 45$$

$$V_{ab} = \frac{25 R_2 + 45(25 + R_2)}{25 + R_2} I$$

$$V_{ab} (25 + R_2) = 25 R_2 I + 45 (25 + R_2) I$$

$$25 V_{ab} + V_{ab} R_2 = 25 R_2 I + 45 R_2 I + 1125 I$$

$$25 V_{ab} - 1125 I = (25 I + 45 I - V_{ab}) R_2$$

$$150 - 106.9 = (3.375 + 4.275 - 6) R_2$$

$$43.1 = 0.65 R_2$$

$$\boxed{R_2 = 66 \Omega}$$

For R_1, R_2

$$R_{eq}^* = \frac{25 \cdot 66}{25 + 66} = 18.1$$

$$V_{R_2}^* = 0.095 R_{eq}^* = 1.72 \text{ V}$$

$$P = I_2 V_{R_2} = \frac{V_{R_2}^2}{R_2} = \frac{(1.72)^2}{66} = \boxed{4.48 \times 10^{-2} \text{ W}}$$

5.- A beam of electrons (mass of the electron: 9.1×10^{-31} kg and charge of the electron: -1.6×10^{-19} C) moving at a speed of 8×10^4 m/s is undeflected when it passes through an electric field of 5 N/C perpendicular to its path and a magnetic field that is perpendicular to its path and also to that of the electric field. Calculate the strength of the magnetic field.

$$\vec{F} = 0$$

$$eE = vB$$

$$4 \quad \frac{5}{8 \times 10^4} = \frac{5 \times 10^{-4} \text{ T}}{8} = 6.25 \times 10^{-5} \text{ T}$$