KING FAHD UNIVERSITY OF PETROLEUM & MINERALS
ELECTRICAL ENGINEERING DEPARTMENT

EE340-Lab [151] sec #**52**	**Lab Quiz: #1**	**19 Oct 2015**
Name: SOLUTION ____________	**ID**:____________	**Grade**:

Problem 1). A parallel plate capacitor, with separation of 10 cm and free space between them, is charged by 12-V dc source that kept all the time. Determine:

a) The electric field between the plates.

$$\overline{E} = \frac{V_a}{d} = \frac{12V}{10 \times 10^{-2}\ m} = 120\ V/m$$

b) The potential V at the middle between the plates, and at 3 cm from the positive charged plate.

$$V(x) = \frac{V_a}{d}x = E * x$$

$$at\ the\ middle\ \longrightarrow x = 5\ cm \longrightarrow V(5\ cm) = 120 * 5 \times 10^{-2} = 6\ V$$

At 3 cm from the positive charged plate= at 7 cm from 0 V plate

$$\longrightarrow x = 7\ cm \longrightarrow V(7cm) = 120 * 7 \times 10^{-2} = 8.4\ V$$

Problem 2).

a) Twin-wire transmission line is 40 meter long, has a wire diameter of 4 mm, separation of the wires, measured between their centerlines, is 8 mm. Calculate the characteristic impedance of the wire. ($\varepsilon_r = 2.3, \mu_r = 1$)

$$C/l = \frac{\pi\varepsilon}{\ln\left(\frac{h}{a}+\sqrt{\frac{h^2}{a^2}-1}\right)} = \frac{\pi\times 2.3\times\varepsilon_0}{\ln\left(\frac{4}{2}+\sqrt{\frac{4^2}{2^2}-1}\right)} = 48.56\ pF$$

$$L/l = \frac{\mu}{\pi}\ln\left(\frac{2h}{a}\right) = \frac{\mu}{\pi}\ln\left(\frac{2\times 4}{2}\right) = 0.5545\ \mu H$$

$$Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{L/l}{C/l}} = \sqrt{\frac{0.5545\times 10^{-6}}{48.56\times 10^{-12}}} = 106.86\ \Omega$$

b) A Coaxial Transmission line with characteristic impedance of 75Ω and capacitance per unit length of 68 pF/m, calculate the ratio between outer radius and inner radius ($\frac{b}{a}$). ($\varepsilon_r = 2.3, \mu_r = 1$)

$$C/l = \frac{2\pi\varepsilon}{\ln(\frac{b}{a})} \longrightarrow \ln\left(\frac{b}{a}\right) = \frac{2\pi\varepsilon_r\varepsilon_0}{\frac{C}{l}} \longrightarrow \frac{b}{a} = e^{\frac{2\pi\varepsilon_r\varepsilon_0}{C/l}} = \exp\left(\frac{2\pi\times 2.3\times\varepsilon_0}{68\times 10^{-12}}\right) = 6.5587 \approx 6.56$$

Problem 3)

a) Find the potential distribution (i.e. all unknown potential points) inside the structure given in Figure 1. Take a step size of 5 cm in both dimension. (the 20 V plate is NOT touching the other plates)

$$V(i,j) = \frac{1}{4}[V(i+1,j) + V(i-1,j) + V(i.j+1) + V(i,j-1)]$$

$$V_x = \frac{1}{4}[V_y + 0 + 20 + 0] \longrightarrow 4V_x - V_y = 20 \quad (1)$$

$$V_y = \frac{1}{4}[0 + V_x + 20 + 0] \longrightarrow -V_x + 4V_y = 20 \ (2)$$

$$By\ Calculator\ V_x = V_y = \frac{20}{3} = 6.67\ V$$

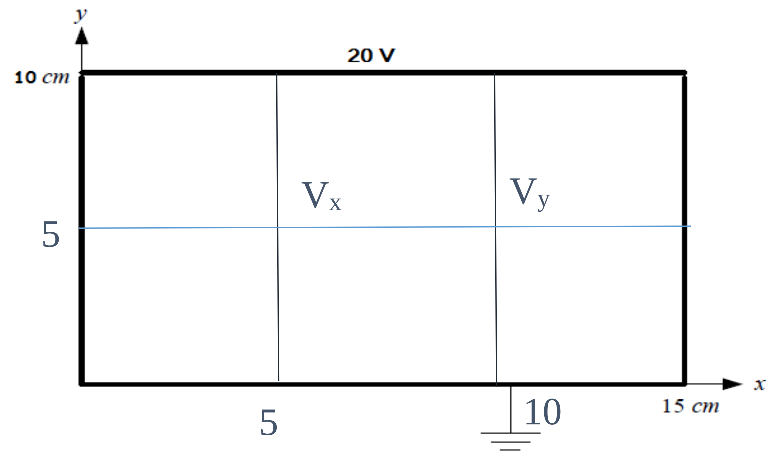


Figure 1

b) Find the <u>First iteration</u> of V_1, V_2 and V_3 in Figure 2, the step size is 5 cm in both dimension.

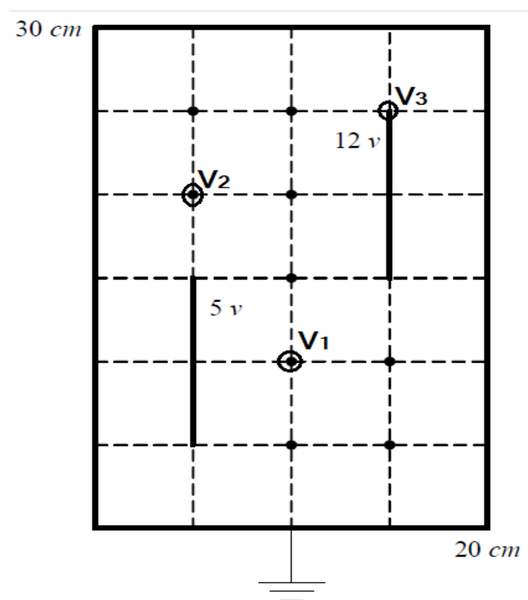
First, Assume all unknown points = 0V

First Iteration:

$$V_1 = \frac{1}{4}[0 + 5 + 0 + 0] = \frac{5}{4} = 1.25\ V$$

$$V_2 = \frac{1}{4}[0 + 0 + 0 + 5] = \frac{5}{4} = 1.25\ V$$

$$V_3 = 12\ V\ (fixed\ value)$$



Formula Sheet

$$\overline{E} = -\nabla\overline{V} = \frac{\partial V}{\partial x}$$

$$\overline{E} = \frac{V_1 - V_0}{x_1 - x_0} = -\frac{V_a}{d}$$

$$\frac{\partial V}{\partial x} = \frac{V_a}{d}$$

$$V(x) = \frac{V_a}{d}x$$

$$\varepsilon_0 = 8.85 \times 10^{-12}\ F/m$$

$$\mu_0 = 4\pi \times 10^{-7}\ H/m$$

$$C/l = \frac{2\pi\varepsilon}{\ln(\frac{b}{a})} \quad ; \quad L/l = \frac{\mu}{2\pi}\ln(\frac{b}{a}).$$

$$C/l = \frac{\pi\varepsilon}{\ln(\frac{h}{a} + \sqrt{\frac{h^2}{a^2} - 1}\ )} \quad ; \quad L/l = \frac{\mu}{\pi}\ln(\frac{2h}{a}).$$

$$Z_0 = \sqrt{\frac{L}{C}}\ .$$

$$\nabla^2 V = 0$$

$$\frac{\partial^2 V}{\partial x^2} + \frac{\partial^2 V}{\partial y^2} = 0$$

$$\frac{\partial^2 V}{\partial x^2} = \frac{V(i+1,j) - 2V(i,j) + V(i-1,j)}{(\nabla x)^2}$$

$$\frac{\partial^2 V}{\partial y^2} = \frac{V(i,j+1) - 2V(i,j) + V(i,j-1)}{(\nabla y)^2}$$

$$V(i,j) = \frac{1}{4}[V(i+1,j) + V(i-1,j) + V(i.j+1) + V(i,j-1)]$$