EE 735 Assignment 1

Due Date: 15th August 2023, 11:59 PM

Hints, assumptions, and instructions:

1. Assume that all the capacitors are enclosed in a big box whose boundaries are maintained at zero potential, i.e., 0 V.
2. Assume that everywhere the thickness of the plate is t=1 nm.
3. The entire dielectric region is charge-free, and ϵr = 1 unless mentioned in the problem.
4. Specify any physical quantity with its units.
5. Please define all input variables at the beginning of your code and use proper comments while developing the code. Your code must work for other input values too.
6. It is mandatory to submit your code along with the report (in pdf) in a single zip folder. Name the file "**Roll Number_ first name _Assignment_1**" for this assignment.

Problems:

Q1: Consider a system of two parallel plates as shown in Figures 1 &2:

(Parameters values are d=8 nm, L= 800nm)

A. Find out the capacitance (per unit width) of the structure by numerically solving the 2d Poisson's equation.
B. Plot the electrostatic potential and equipotential surfaces.
C. Plot the 2d electric field profile.
D. Compare the simulated capacitance with the theoretical value ($C_{th} = \frac{\epsilon L}{d}$). Which one is smaller/larger and why?
E. Now lower half of the region is replaced with another dielectric material (dielectric constant of 5) as shown in Figure 2; repeat parts A, B, C, D. (Pay attention to C_{th}, you need to recalculate as per the new structure)

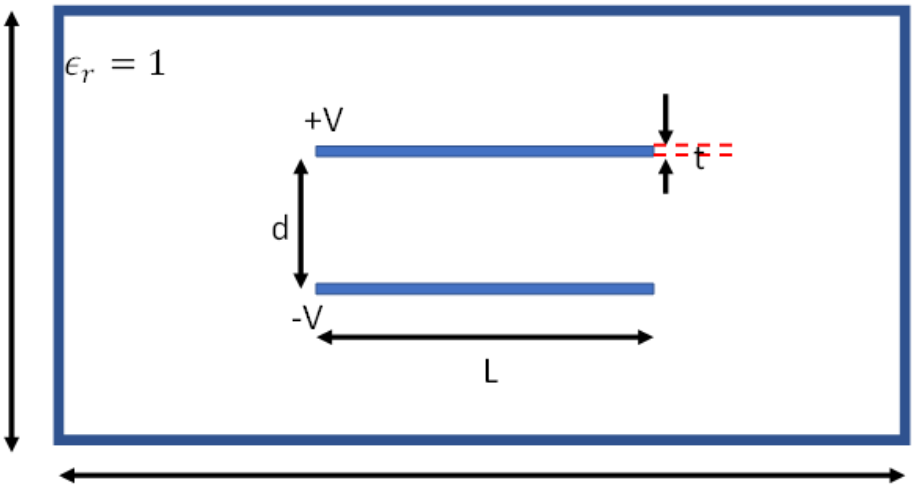

Figure 1: Structure for Q1 parts A, B, C, D

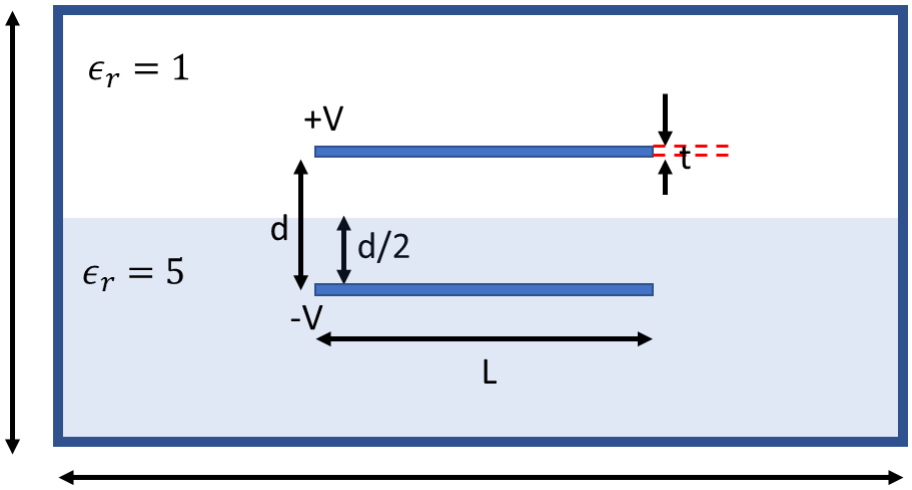

Figure 2: Structure for Q1 Part E

Q2: Now consider a system as shown in Figure 3:

Problem statement: There are three plates (P1, P2, P3) placed as shown in Figure 3. The length (L1) of plate P1 is 500 nm which is fixed for this system. The lengths of P2 and P3 are the same, L2 = L3. Now d_2 is the variable distance between P2 and P3 such that L2+L3+d_2 = L1 and d_1 = 5nm (fixed). P2 is at 5 V, and P1 is at -5 V for this entire exercise. Starting with d_2 = 30 nm, increase it till 90 nm in 30 nm steps with plate P3 at (V_3) 0 V, +5 V, and -5 V.

A. Find out the capacitance (per unit width) of the structure by numerically solving the 2d Poisson's equation for all 9 cases. (Hint: First fix the voltage level of P3 and change d_2 or vice-versa)
B. Plot the electrostatic potential and equipotential surfaces for all cases.
C. Plot the 2d electric field profile and find out the position of the maximum electric field for all cases.
D. Note and explain the observations from your simulation results of A, B, and C.

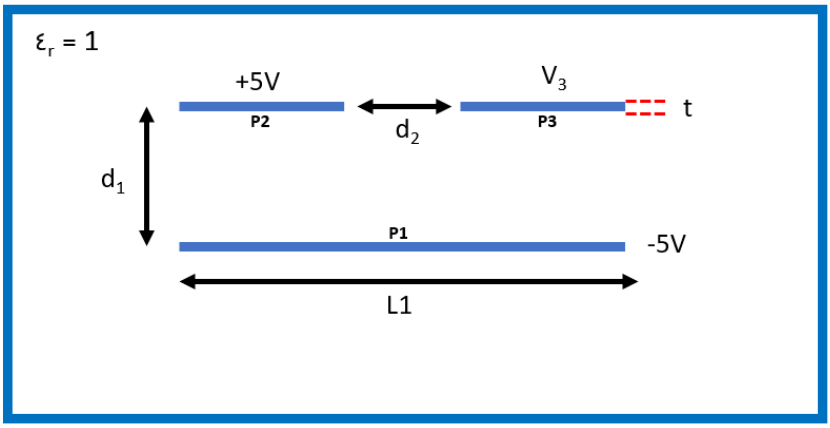

Figure 3: Structure for Q3

Q3: For the structure in *Figure 1*,

A. Vary L from 20 nm to 1500 nm. Plot C as a function of L.
B. Calculate the parasitic capacitance $C_p(L) = C(L) - C_{th}(L)$ and plot it as a function of L. Qualitatively explain the nature of the plot.

**********END OF ASSIGNMENT 1**********