Homework #3

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Calculation of capacitance per unit area of hetero-structure (GaAs/InAs) and compare the potential calculated by using numerical method with that by using analytical solution.

I choose GaAs (2 nm) / InAs (8 nm) hetero structure. The dielectric constants are 12.5 and 14.6, respectively and the heterosctructure is applied at 1 V.

Table 1. Calculation parameters

	GaAs	InAs
Thickness (nm)	2	8
Dielectric constant	12.5	14.6

Numerically calculate the capacitance of the heterostructure (GaAs/InAs). Potential (fig.1). Assume the each layer is charged 1×10^{-6} Coulomb. Using properties of capacitance in series, we can calculate each capacitance.

$$Q = C_1 V_1 = C_2 V_2 = CV$$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$V = V_1 + V_2$$

Table 2. Calculation results from Matlab code

Component	Numerical method	Analytical method
V_1/V_2	0.2944	0.2944
C_1 [F]	4.3973×10^{-6}	4.3973×10^{-6}
C_2 [F]	1.2944×10^{-6}	1.2944×10^{-6}
C [F]	1×10^{-6}	1×10^{-6}
C [F/m^2]	0.0125	0.0125

Area=8.0102×10^{-5}

from $C = \frac{\varepsilon_0 \varepsilon_1}{d} A$

Analytical solution is

$$V = \frac{V(x=2) * x}{10}; \quad 0 \le x \le 2$$

$$V = \frac{10 * V(x=2) - 2 + (1 - V(x=2) * x}{8}; \quad 2 < x \le 10$$

Figiure 1 shows potentials calculated by numerical and analytical methods. The solution from the different method indicates same values.
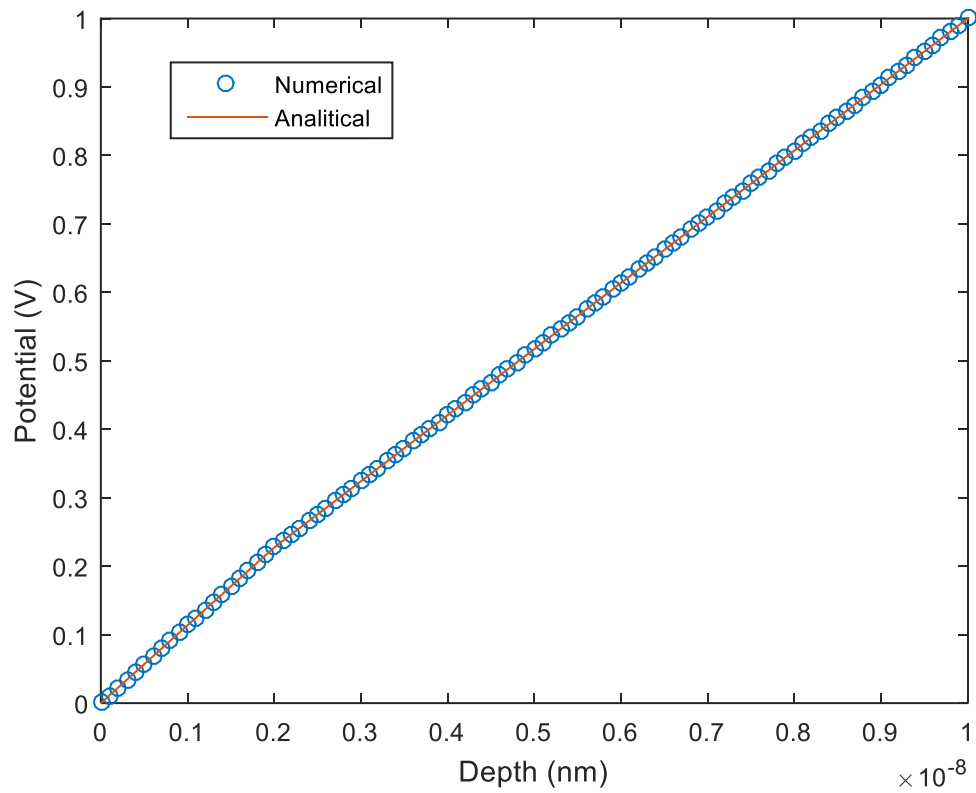

Figure 1. Potential of function of depth. Blue circle symbol and red line are calculated by numerical method and analytical method, respectively.