Birla Institute of Technology and Science, Pilani

First Semester 2017-18 End-Semester Examination (Closed Book)

Course Title: Nanoelectronics & Nanophotonics Course No. EEE G595
Maximum Marks: 80 Maximum Time: 120 Minutes Dated: 06/12/2017

1. Show that

$$\int_0^\infty \left[(N_k+1)e^{i(E_q-E_k-\hbar\omega)(t'-t)/\hbar} + N_k e^{i(E_q-E_k+\hbar\omega)(t'-t)/\hbar}\right]dt' = \hbar\pi\left[(N_k+1)\delta(E_q-E_k-\hbar\omega)+N_k\delta(E_q-E_k+\hbar\omega)\right]$$

[10]

2. From the expression of the Hamiltonian in the presence of Electromagnetic Field,

$$H=\frac{1}{2m_0}\left(\vec{p}-\frac{e\vec{A}}{c}\right)^2 - e\varphi + V_0(\vec{r})$$

obtain the Hamiltonian for the for the composite system(electron+photon) using radiation gauge.

[10]

3. From the expression of the photon emission probability,

$$P_{q\leftarrow k}^{em}=\frac{e^2\hbar^2(N_S+1)\left|\langle q|\hat{e}_S\bullet\nabla|k\rangle\right|^2}{2m_0^2\varepsilon\omega_S\Omega}\frac{\Gamma_K}{\left[(E_q-E_k-\hbar\omega)^2+\Gamma_K^2\right]}$$

separate out the expressions for spontaneous and simulated probabilities.

[10]

4. (a) Applying Unitary operation $U=e^{iH_0t/\hbar}$ on $|\psi(t)\rangle$ i.e, $e^{iH_0t/\hbar}|\psi(t)\rangle \rightarrow |\hat{\psi}(t)\rangle$ transform the Schrodinger equation $i\hbar\frac{\partial|\psi(t)\rangle}{\partial t}=(H_0+V')|\psi(t)\rangle$ into interaction picture. [10]

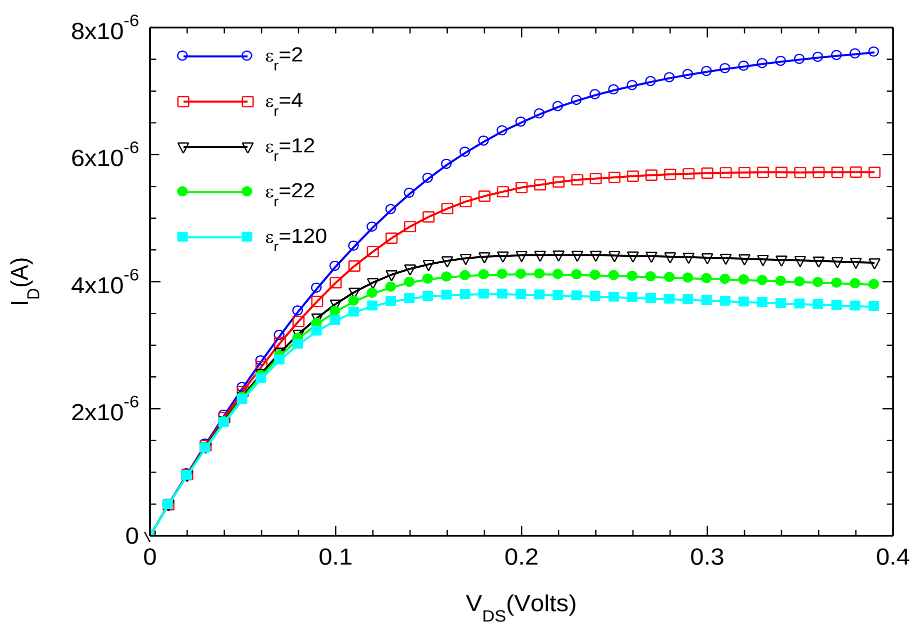
(b) Now, from the time-development operator $\hat{T}(t)=1-\frac{i}{\hbar}\int_0^t \hat{V}'(t')\hat{T}(t')dt'$, obtain the most generic expression of the transition probability amplitude for $|k\rangle \rightarrow |q\rangle$. Also, show that the Schrodinger equation of the interaction picture satisfies the integral equation for $\hat{T}(t)$. [10]

(c) Applying First-Order Perturbation theory and assuming V' to be time-independent, show that the there is an exponential decay of the electron occupation probability in the initial state $|k\rangle$.

[10]

5. (a) Considering electrons as particles, show that the total resistance of a two terminal device can be given as a sum of interface resistance and device resistance. [10]

(b) The change in the shape of the output characteristics of a nano-scale MOSFET when the dielectric constant ε_r of the oxide layer which is varied from 2 to 120 is shown in the figure below. Explain why the saturation current is maximum when ε_r is 2. [10]



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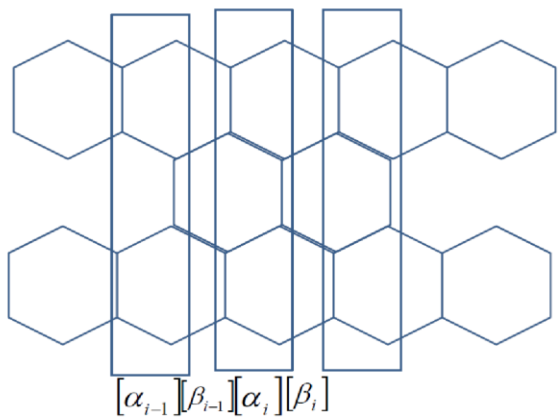
Birla Institute of Technology and Science, Pilani

First Semester 2017-18 End-Semester Examination (Open Book)

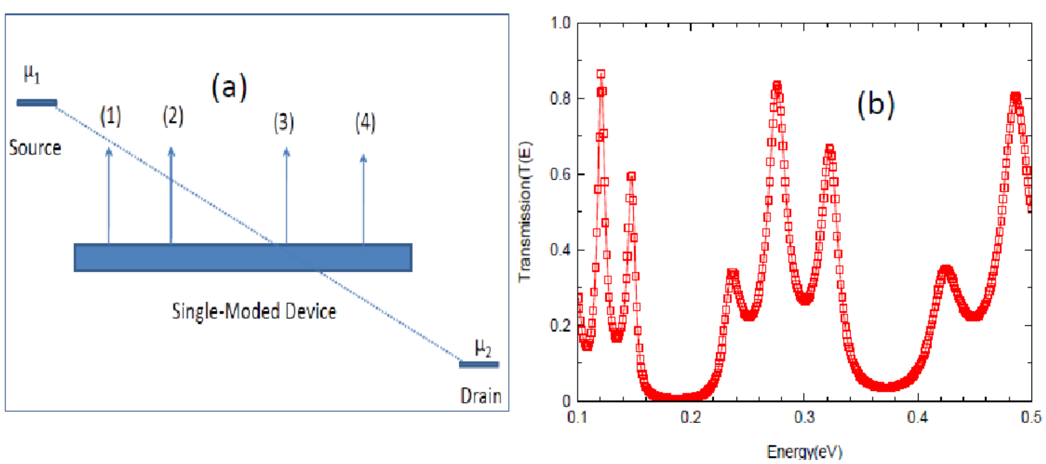
Course Title: Nanoelectronics & Nanophotonics Course No. EEE G595
Maximum Marks: 40 Maximum Time: 60 Minutes Dated: 06/12/2016

1. The discretization of a Zigzag Graphene Nanoribbon is shown in the figure.



Construct [H], $[\alpha_i]$ and $[\beta_i]$ matrices for this system. [15]

2. The figure show a schematic of a Single-Moded Nano-scale Device with Scatterers at 1, 2, 3 and 4 and its Transmission, T(E) for the device which is obtained from the NEGF procedure.



(a) Write a complete NEGF procedure for obtaining the transmission T(E). [15]

(b) Also, explain the dips and peaks in the transmission function. [10]

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