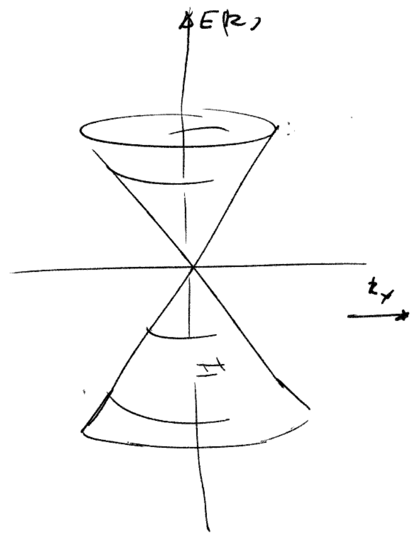
The E vs (k_x, k_y) diagram for graphene, a 2D material, is given by $E_\pm = \pm\hbar v_F k$ where $v_F = 10^8$ cm/s. An electric field is applied by a voltage V_G to a parallel metal plate separated from the graphene sheet by a 500 nm thick film of SiO_2. The Fermi level is at 0 eV when $V_G = 0$.



A. (1 pt) Calculate the density of states in the conduction band as a function of E from the Fermi level set at $V_G = 0$. Note that the bands are doubly degenerate and there is electron spin.

B. (2 pts) Find the position of the Fermi level when $V_G = 20V$, negative with respect to the graphene at $T = 0K$. How does this result change at room temperature?

C. (1 pt) The graphene Bravais lattice vectors are $\vec{a_1} = a/2\,\hat{x} - a\sqrt{3}/2\,\hat{y}$ and $\vec{a_2} = a/2\,\hat{x} + a\sqrt{3}/2\,\hat{y}$ with basis vectors $u_1 = 0$ and $\vec{u_2} = 1/3\,\vec{a_1} + 2/3\,\vec{a_2}$. Draw the lattice. If the lattice parameter of graphene is 2.47 Å, what is the atomic density? From the result of the previous part, how many electrons per atom are added by application of $V_G = 20$ V?

q	1.6×10^{-19} C	electron charge
ϵ_o	8.85×10^{-14} F/cm	permittivity of free space
K_s	11.8 (Si)	relative dielectric constant
K_o	3.9 (SiO_2)	relative dielectric constant
k_B	8.617×10^{-5} eV/K	Boltzman's constant
h	6.63×10^{-34} J s	Planck constant
m_o	9.11×10^{-31} kg	electron mass
k_BT/q	0.0259 V at 300 K	thermal voltage
c	3×10^8 m/s	speed of light