Write a MATLAB script to plot the mobility vs. electron concentration for graphene. Your plot should be for room temperature, 300 K, and should cover sheet electron densities from $n_s = 0.1 \times 10^{13}$ to $1.0 \times 10^{13}$ cm$^{-2}$. You should consider three cases:

i) acoustic phonon scattering  
ii) charged impurity scattering  
iii) both acoustic phonon and ionized impurity scattering.

The following information should be useful.

The dispersion of graphene is:  
$$E(k) = \pm \hbar v_F |\vec{k}| = \pm \hbar v_F \sqrt{k_x^2 + k_y^2}.$$

The “Fermi velocity” of graphene is:  
$$v_F = 10^8 \text{ cm/s}.$$

The density of states of graphene is:  
$$D_{2D}(E) = \frac{2}{\pi \hbar^2 v_F^2} |E| \text{ cm}^{-2}.$$

The net electron density in the “conduction band” (i.e. $E > 0$) is  
$$n_s = n - p = \int_0^{\infty} D_{2D}(E) f_0(E) dE - \int_{-\infty}^0 D_{2D}(E)[1 - f_0(E)] dE.$$

The momentum relaxation rate due to acoustic phonon scattering is:  
$$\frac{1}{\tau_m(E)} = \frac{D_A^2 k_B T}{4 \hbar^3 \rho \mu v_F^2 v_S^2} E \text{ s}^{-1}.$$

The velocity of LA acoustic phonons in graphene is  
$$v_S = 2.1 \times 10^6 \text{ cm/s}.$$

The mass density of graphene is:  
$$\rho_m = 7.6 \times 10^{-7} \text{ kg m}^{-2}.$$

The acoustic deformation potential is:  
$$D_A = 18 \pm 1 \text{ eV}.$$

Charged impurity scattering depends on the concentration of charged impurities. Assume that the momentum relaxation time is given by  
$$\tau_m(E) = \left(3 \times 10^6 \text{ sJ}^{-1}ight) E \text{ s}.$$
The final result of your script should be three plots of electron mobility vs. sheet carrier density from \( n_s = 0.1 \times 10^{13} \) to \( n_s = 1.0 \times 10^{13} \) cm\(^2\):

i) only acoustic phonon scattering

ii) only charged impurity scattering

iii) both acoustic phonon and charged impurity scattering.

**HINT:** A good way to start is to plot \( n_s \) vs. \( E_F \) for \( E_F > 0 \) and determine the range of Fermi levels that need to be considered. Then plot \( \sigma \left( E_F \right) \) over this range, and you are off to a good start.

Your script should be clear and easy to understand. It should contact a header that explains the purpose of the script and who wrote it and when. It should be well-documented. The size of the labels should be chosen so that the plot could be pasted in a PowerPoint presentation and be readable by an audience.

You will receive credit for this assignment if your script works properly. The best script (and there may be several people tied for best) will receive additional credit.