Gate Assignment

EE:1205 Signals and Systems
Indian Institute of Technology, Hyderabad

Kunal Thorawade
EE23BTECH11035

Question: A Spectrometer is used to detect plasma oscillations in a sample. The spectrometer can work in the range of 3 x 10^{12} rad s^{-1} to 30 x 10^{12} rad s^{-1}. The minimum carrier concentration that can be detected by using this spectrometer is n x 10^{21} m^{-3}. The value of n is _____. (Round off to two decimal places)
(Charge on electron = -1.6 x 10^{-19} C^{-1}, mass of electron = 9.1 x 10^{-31} kg and ϵ_0 = 8.85 x 10^{-12} C^2 N^{-1} m^{-2}) (GATE PH 35 2022)

Solution:

Parameter	Value	Description
ω_{p1}	3 x 10^{12} rad s^{-1}	Lower bound of plasma frequency
ω_{p2}	30 x 10^{12} rad s^{-1}	Upper bound of plasma frequency
$\Delta\omega_p = \omega_{p2} - \omega_{p1}$	27 x 10^{12} rad s^{-1}	Plasma Frequency
n_0	n x 10^{21}	Minimum carrier concentration
e	-1.6 x 10^{-19}	Charge on electron
m	9.1 x 10^{-31}	Mass of electron

TABLE 1
Parameter Table

$$\Delta\omega_p = \sqrt{\frac{n_0 e^2}{m\epsilon_0}} \tag{1}$$

$$\implies n_0 = \frac{\left(\Delta\omega_p\right)^2 m\epsilon_0}{e^2} \tag{2}$$

$$n_0 = \frac{\left(27\text{x}10^{12}\right)^2 \text{x}\left(9.1\text{x}10^{31}\right)\text{x}\left(8.85\text{x}10^{-12}\right)}{\left(-1.6\text{x}10^{-19}\right)^2} \tag{3}$$

$$\therefore n_0 = 2.83\text{x}10^{21}\text{m}^{-3} \tag{4}$$

$$n = n_0\text{x}10^{-21} \tag{5}$$

$$\therefore n = 2.83 \tag{6}$$