# Gate Assignment

EE:1205 Signals and Systems
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**Question**: A Spectrometer is used to detect plasma oscillations in a sample. The spectrometer can work in the range of $3\times10^{12}$ rad $s^{-1}$ to $30\times10^{12}$ rad $s^{-1}$. The minimum carrier concentration that can be detected by using this spectrometer is $n \times 10^{21}$ $m^{-3}$. The value of $n$ is _____. (Round off to two places)
(Charge on electron = $-1.6 \times 10^{-19}$ $C^{-1}$, mass of electron = $9.1 \times 10^{-31}$ kg and $\epsilon_0 = 8.85 \times 10^{-12}$ $C^2$ $N^{-1}$ $m^{-2}$ ) (GATE PH 35 2022)

**Solution:**

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

TABLE 1
Parameter Table

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

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

$$n_0 = \frac{\left(27\times10^{12}\right)^2 \times \left(9.1\times10^{31}\right) \times \left(8.85\times10^{-12}\right)}{\left(-1.6\times10^{-19}\right)^2} \tag{3}$$

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

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

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

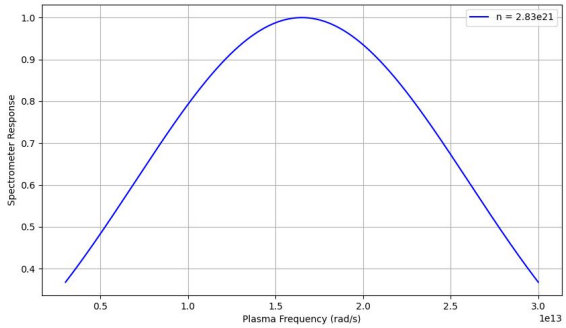


Fig. 1. Plot of Spectrometer response vs Plasma frequency