Answer on Question#56089 - Physics - Other

Suppose the maximum safe average intensity of microwaves for human exposure is taken to be $I = 1.50\,\frac{\mathrm{W}}{\mathrm{m}^2}$. If a radar unit leaks $P = 10.0\mathrm{W}$ of microwaves (other than those sent by its antenna) uniformly in all directions, how far away must you be to be exposed to an average intensity considered to be safe? Assume that the power spreads uniformly over the area of a sphere with no complications from absorption or reflection.

Answer in Meter What is the maximum electric field strength at this distance? Answer in V/m

Solution:

Since the surface area of the sphere of radius r is given by $S = 4\pi r^2$, the intensity of microwaves at distance r is

$$I(r) = \frac{P}{S} = \frac{P}{4\pi r^2}$$

It is given that $I(r)$ must be equal I, for human to be safe:

$$\frac{P}{4\pi r^2} = I$$

Therefore

$$r = \sqrt{\frac{P}{4\pi I}} = \sqrt{\frac{10.0\mathrm{W}}{4\pi \cdot 1.50\,\frac{\mathrm{W}}{\mathrm{m}^2}}} = 0.73\mathrm{m}$$

The total energy density at this distance is $\frac{I}{c}$. At the same time it can be expressed through the electric field strength E:

$$\varepsilon_0 E^2$$

Therefore

$$\frac{I}{c} = \varepsilon_0 E^2$$

$$E = \sqrt{\frac{I}{\varepsilon_0 c}} = \sqrt{\frac{1.5\,\frac{\mathrm{W}}{\mathrm{m}^2}}{8.854 \times 10^{-12}\,\frac{\mathrm{C}}{\mathrm{V}\cdot\mathrm{m}} \cdot 3 \times 10^8\,\frac{\mathrm{m}}{\mathrm{s}}}} = 23.76\,\frac{\mathrm{V}}{\mathrm{m}}$$

Answer: $r = 0.73\mathrm{m}$, $E = 23.76\,\frac{\mathrm{V}}{\mathrm{m}}$.