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$$\epsilon_0 = 8.85 \times 10^{-12} \frac{\mathrm{J}}{\mathrm{m} \cdot \mathrm{V}^2}$$

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(b) What is the energy density of the electromagnetic wave?
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Physics 11 - Quiz 16 5/-7/2020

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Solution:

(a)

$$I = \frac{P}{A} = \frac{1.5\text{mW}}{0.5\text{m}^2} = 3 \times 10^{-3} \frac{\text{W}}{\text{m}^2} = 3 \times 10^{-3} \frac{\text{J/s}}{\text{m}^2}$$

(b)

$$I = uc \longrightarrow u = \frac{I}{c} = 1 \times 10^{-11} \frac{\text{J}}{\text{m}^3}$$

(c)

$$u = \tfrac{1}{2}\epsilon_0 E^2 \longrightarrow E = \sqrt{\frac{2u}{\epsilon_0}} = \sqrt{\frac{2 \times 10^{-11} \frac{\text{J}}{\text{m}^3}}{8.85 \times 10^{-12} \frac{\text{J}}{\text{m} \cdot \text{V}^2}}} = 1.5 \frac{\text{V}}{\text{m}}$$