2.77 A uniform plane wave, with a power density of 10 mwatts/cm^2, is impinging upon a *half wavelength* dipole at an angle normal/perpendicular to the axis of the dipole. Determine the:

(a) *Maximum effective area* (*in* λ^2) of the *lossless dipole element.* Assume the dipole has a directivity of 2.148 dB, it is *polarized matched* to the incident wave and it is *mismatched*, with reflection coefficient of 0.2 to the transmission line it is connected.

(b) *Physical area* (*in* λ^2). Assume the physical area of the dipole is equal to its lengthwise cross sectional area; the dipole *diameter is* $\lambda/300$.

(c) *Aperture efficiency* (*in* %).

(d) *Maximum power* the dipole will interecept and deliver to a load. Assume a frequency of operation of *1 GHz*.

a) Use (2-112), $A_{em} = e_{cd}\,(1-|\Gamma|^2)\left(\frac{\lambda^2}{4\pi}\right)D_0\,|\hat{\rho}_w \bullet \hat{\rho}_a|^2 = e_{cd}\,(1-|\Gamma|^2)\left(\frac{\lambda^2}{4\pi}\right)D_0\,(\text{PLF})$

where $e_{cd} = 1$ (lossless), $D_0 = 10^{D0\text{ (dB)}/10} = 10^{2.148/10} = 1.63983$, $|\Gamma| = 0.2$, and PLF = 1 (polarization-matched). This yields

$$A_{em} = 1\,(1-0.2^2)\left(\frac{\lambda^2}{4\pi}\right)1.63983443\,(1) \qquad \Rightarrow \qquad \underline{\mathbf{A_{em} = 0.125274\,\lambda^2}}.$$

b) Slicing the dipole lengthwise yields a rectangular area of

$$A_p = \ell\, d = (\lambda/2)(\lambda/300) \qquad \Rightarrow \qquad \underline{\mathbf{A_p = 0.00166667\,\lambda^2}}.$$

c) Use (2-100), $\varepsilon_{ap} = \frac{A_{em}}{A_p} = \frac{0.125274\,\lambda^2}{0.00166667\,\lambda^2} = 75.1644 \qquad \Rightarrow \qquad \underline{\mathbf{\varepsilon_{ap} = 7516.44\%}}.$

d) Use (2-94), $A_e = \frac{P_T}{W_i}$.

At 1 GHz, the wavelength is $\lambda = c\,/\,f = 2.9979\times10^8\,/\,1\times10^9 = 0.29979\text{ m} = 29.979\text{ cm}$

$$P_{T,\max} = A_{em}\,W_i = 0.125274(29.979\text{ cm})^2\,10\times10^{-3}\text{ W/cm}^2 \qquad \Rightarrow \qquad \underline{\mathbf{P_{T,\max} = 1.12589\text{ W}}}.$$