4.34 A small dipole of length $l = \lambda/20$ and of wire radius $a = \lambda/400$ is fed symmetrically, and it is used as a communications antenna at the lower end of the VHF band ($f = 30$ *MHz*). *The antenna is made of perfect electric conductor (PEC).* The *input reactance* of the dipole is given by

$$X_{in} = -j120\frac{[\ln(l/2a) - 1]}{\tan\left(\frac{\pi l}{\lambda}\right)}$$

Determine the following:

(a) Input impedance of the antenna. *State whether it is inductive or capacitive.*

(b) Radiation efficiency (*in percent*).

(c) Capacitor (*in farads*) *or* inductor (*in henries*) that must be connected *in series* with the dipole at the feed in order to resonate the element. *Specify which element is used and its value.*

a) Per (4-37), $R_r = 20\pi^2(l/\lambda)^2 = 20\pi^2(1/20)^2$

$$R_r = 0.49348\ \Omega$$

$$X_{in} = -j120\,\frac{\ln\left(\frac{\lambda/20}{2(\lambda/400)}\right) - 1}{\tan\left(\frac{\pi\,\lambda/20}{\lambda}\right)} = -j986.9038\ \Omega$$

$$\underline{Z_{in} = 0.4935 - j986.9038\ \Omega} \quad \underline{\text{capacitive}}$$

b) Since antenna is made of a PEC.

$$\Rightarrow e_{cd} = \frac{R_r}{R_r + \cancel{R_L}^{\,0}} \times 100\% = \underline{100\%}$$

c) To cancel out the capacitive reactance, we need an <u>inductor</u> such that

$$\omega L = 2\pi(30\times10^6)L = +986.9038\ \Omega$$

$$\hookrightarrow \underline{L = 5.236\times10^{-6}\,H = 5.236\,\mu H}$$