**Problem 8.1**

Example 7.13.

$$\left.\begin{aligned}\mathbf{E} &= \frac{\lambda}{2\pi\epsilon_0}\frac{1}{s}\,\hat{\mathbf{s}}\\ \mathbf{B} &= \frac{\mu_0 I}{2\pi}\frac{1}{s}\,\hat{\boldsymbol{\phi}}\end{aligned}\right\}\mathbf{S} = \frac{1}{\mu_0}(\mathbf{E}\times\mathbf{B}) = \frac{\lambda I}{4\pi^2\epsilon_0}\frac{1}{s^2}\,\hat{\mathbf{z}};$$

$$P = \int \mathbf{S}\cdot d\mathbf{a} = \int_a^b S\,2\pi s\,ds = \frac{\lambda I}{2\pi\epsilon_0}\int_a^b \frac{1}{s}\,ds = \frac{\lambda I}{2\pi\epsilon_0}\ln(b/a).$$

$$\text{But } V = \int_a^b \mathbf{E}\cdot d\mathbf{l} = \frac{\lambda}{2\pi\epsilon_0}\int_a^b \frac{1}{s}\,ds = \frac{\lambda}{2\pi\epsilon_0}\ln(b/a), \text{ so } \boxed{P = IV.}$$

Problem 7.62.

$$\left.\begin{aligned}\mathbf{E} &= \frac{\sigma}{\epsilon_0}\,\hat{\mathbf{z}}\\ \mathbf{B} &= \mu_0 K\,\hat{\mathbf{x}} = \frac{\mu_0 I}{w}\,\hat{\mathbf{x}}\end{aligned}\right\}\mathbf{S} = \frac{1}{\mu_0}(\mathbf{E}\times\mathbf{B}) = \frac{\sigma I}{\epsilon_0 w}\,\hat{\mathbf{y}};$$

$$P = \int \mathbf{S}\cdot d\mathbf{a} = Swh = \frac{\sigma I h}{\epsilon_0}, \text{ but } V = \int \mathbf{E}\cdot d\mathbf{l} = \frac{\sigma}{\epsilon_0}h, \text{ so } \boxed{P = IV.}$$

**Problem 8.2**

(a) $\mathbf{E} = \frac{\sigma}{\epsilon_0}\,\hat{\mathbf{z}};\ \sigma = \frac{Q}{\pi a^2};\ Q(t) = It\ \Rightarrow\ \mathbf{E}(t) = \boxed{\frac{It}{\pi\epsilon_0 a^2}\,\hat{\mathbf{z}}.}$

$$B\,2\pi s = \mu_0\epsilon_0\frac{\partial E}{\partial t}\pi s^2 = \mu_0\epsilon_0\frac{I\pi s^2}{\pi\epsilon_0 a^2}\ \Rightarrow\ \mathbf{B}(s,t) = \boxed{\frac{\mu_0 I s}{2\pi a^2}\,\hat{\boldsymbol{\phi}}.}$$

(b) $u_{\text{em}} = \frac{1}{2}\left(\epsilon_0 E^2 + \frac{1}{\mu_0}B^2\right) = \frac{1}{2}\left[\epsilon_0\left(\frac{It}{\pi\epsilon_0 a^2}\right)^2 + \frac{1}{\mu_0}\left(\frac{\mu_0 I s}{2\pi a^2}\right)^2\right] = \boxed{\frac{\mu_0 I^2}{2\pi^2 a^4}\left[(ct)^2 + (s/2)^2\right].}$

$$\mathbf{S} = \frac{1}{\mu_0}(\mathbf{E}\times\mathbf{B}) = \frac{1}{\mu_0}\left(\frac{It}{\pi\epsilon_0 a^2}\right)\left(\frac{\mu_0 I s}{2\pi a^2}\right)(-\hat{\mathbf{s}}) = \boxed{-\frac{I^2 t}{2\pi^2\epsilon_0 a^4}\,s\,\hat{\mathbf{s}}.}$$

$$\frac{\partial u_{\text{em}}}{\partial t} = \frac{\mu_0 I^2}{2\pi^2 a^4}2c^2 t = \frac{I^2 t}{\pi^2\epsilon_0 a^4};\quad -\boldsymbol{\nabla}\cdot\mathbf{S} = \frac{I^2 t}{2\pi^2\epsilon_0 a^4}\boldsymbol{\nabla}\cdot(s\,\hat{\mathbf{s}}) = \frac{I^2 t}{\pi^2\epsilon_0 a^4} = \frac{\partial u_{\text{em}}}{\partial t}.\ \checkmark$$

(c) $U_{\text{em}} = \int u_{\text{em}} w 2\pi s\,ds = 2\pi w\frac{\mu_0 I^2}{2\pi^2 a^4}\int_0^b [(ct)^2 + (s/2)^2]s\,ds = \frac{\mu_0 w I^2}{\pi a^4}\left[(ct)^2\frac{s^2}{2} + \frac{1}{4}\frac{s^4}{4}\right]\Big|_0^b$

$= \boxed{\frac{\mu_0 w I^2 b^2}{2\pi a^4}\left[(ct)^2 + \frac{b^2}{8}\right].}$ Over a surface at radius $b$: $P_{\text{in}} = -\int \mathbf{S}\cdot d\mathbf{a} = \frac{I^2 t}{2\pi^2\epsilon_0 a^4}\left[b\,\hat{\mathbf{s}}\cdot(2\pi b w\,\hat{\mathbf{s}})\right] = \boxed{\frac{I^2 w t b^2}{\pi\epsilon_0 a^4}.}$

$\frac{dU_{\text{em}}}{dt} = \frac{\mu_0 w I^2 b^2}{2\pi a^4}2c^2 t = \frac{I^2 w t b^2}{\pi\epsilon_0 a^4} = P_{\text{in}}.\ \checkmark$ (Set $b = a$ for *total*.)