① a) $V_{capacitor} = \frac{Qd}{A\varepsilon_0}$

$V(t) = V_0 \cos(\omega t) = \frac{Qd}{A\varepsilon_0}\cos(\omega t)$

$\rightarrow Q(t) = Q\cos(\omega t)$ (Q é a única grandeza em $\frac{Qd}{A\varepsilon_0}$ que pode variar com o tempo)

$\int E\,dA = \frac{Q(t)}{\varepsilon_0}$

$E(t)\pi R^2 = \frac{Q\cos(\omega t)}{\varepsilon_0} \rightarrow \vec{E} = \frac{Q\cos(\omega t)}{\pi R^2 \varepsilon_0}\hat{x}$

b) $u_E = \frac{\varepsilon_0 E^2}{2} = \frac{\varepsilon_0 Q^2\cos^2(\omega t)}{2\pi^2 R^4 \varepsilon_0^2} = \frac{Q^2\cos^2(\omega t)}{2\pi^2 R^4 \varepsilon_0}$

c) $\vec{\nabla}\times\vec{B} = \cancel{\mu_0\vec{J}} + \mu_0\varepsilon_0 \frac{\partial \vec{E}}{\partial t}$

$r<R$ $\quad \int \vec{B}\cdot d\vec{l} = \mu_0\varepsilon_0 \int \frac{Q(-\omega \operatorname{sen}\omega t)}{\pi R^2 \varepsilon_0}\hat{x}\cdot d\vec{A}$

$B2\pi r = -\frac{\mu_0 Q\omega \operatorname{sen}(\omega t)\cancel{\pi} r^2}{\cancel{\pi} R^2}$

$\vec{B} = -\frac{\mu_0 Q\omega \operatorname{sen}(\omega t) r}{2\pi R^2}\hat{\theta}$

$r>R$ $\quad B2\pi r = -\frac{\mu_0 Q\omega \operatorname{sen}(\omega t)\cancel{\pi R^2}}{\cancel{\pi R^2}}$

$\vec{B} = -\frac{\mu_0 Q\omega \operatorname{sen}(\omega t)}{2\pi r}\hat{\theta}$

d) $u_B = \frac{B^2}{2\mu_0} = \frac{\mu_0 Q^2\omega^2 \operatorname{sen}^2(\omega t) r^2}{8\pi^2 R^4}$

e) $U_E = \int u_E\,dV = \frac{Q^2\cos^2(\omega t)}{2\pi^2 R^4 \varepsilon_0}\pi R^2 d = \frac{Q^2 d\cos^2(\omega t)}{2\pi R^2 \varepsilon_0}$

$\langle U_E\rangle = \frac{Q^2 d}{2\pi R^2\varepsilon_0}\langle\cos^2\omega t\rangle \rightarrow \frac{\int_0^{\frac{2\pi}{\omega}}\cos^2(\omega t)dt}{\frac{2\pi}{\omega}} = \frac{\cancel{\frac{2\pi}{\omega}}\cdot\frac{1}{2}}{\cancel{\frac{2\pi}{\omega}}} = \frac{1}{2}$

$= \frac{Q^2 d}{4\pi R^2\varepsilon_0}$

f) $U_B = \int u_B\,dV = \frac{\mu_0 Q^2\omega^2 \operatorname{sen}^2(\omega t)}{8\pi^2 R^4}\int r^2 r\,dr\,d\theta\,dx = \frac{\mu_0 Q^2\omega^2 \operatorname{sen}^2(\omega t)\,2\pi d R^4}{32\pi^2 R^4} = \frac{\mu_0 Q^2\omega^2 \operatorname{sen}^2(\omega t) d}{16\pi}$

$\langle U_B\rangle = \frac{\mu_0 Q^2\omega^2 d}{32\pi}$

$\frac{\langle U_B\rangle}{\langle U_E\rangle} = \frac{\mu_0 \cancel{Q^2}\omega^2 \cancel{d}}{32\cancel{\pi}}\,\frac{4\cancel{\pi} R^2\varepsilon_0}{\cancel{Q^2}\cancel{d}} = \frac{\mu_0\varepsilon_0\omega^2 R^2}{8} = \frac{\omega^2 R^2}{8c^2}$

g) $\vec{\nabla}\times\vec{E}_F = -\dfrac{\partial \vec{B}}{\partial t}$ 

$$\int \vec{E}_F\cdot d\vec{l} = -\frac{\mu_0 Q \omega^2 \cos(\omega t)}{2\pi R^2}\int r' dr' dx$$

$$E_F\, d = -\frac{\mu_0 Q \omega^2 \cos(\omega t)}{2\pi R^2}\,\frac{r^2}{2} d$$

$$E_F = -\frac{\mu_0 Q \omega^2 \cos(\omega t) r^2}{4\pi R^2}\hat{x}$$

$$\frac{|E|}{|E_F|} = \frac{Q\cos(\omega t)}{\pi R^2 \varepsilon_0}\,\frac{4\pi R^2}{\mu_0 Q\omega^2 \cos(\omega t) r^2} = \frac{4}{\mu_0\varepsilon_0\omega^2 r^2} = \frac{4c^2}{\omega^2 r^2}$$

② a) $\int \vec{B}\cdot d\vec{l} = \mu_0 N I$

$$B\cdot l = \mu_0 N I \rightarrow \vec{B} = \mu_0 n I_{(t)}\hat{x}$$

b) $$u_B = \frac{B^2}{2\mu_0} = \frac{\mu_0 n^2 I_{(t)}^2}{2} = \frac{\mu_0 n^2 I_0^2 \cos^2(\omega t)}{2}$$

c) $\vec{\nabla}\times\vec{E} = -\dfrac{\partial \vec{B}}{\partial t}$

$$\int \vec{E}\cdot d\vec{l} = +\mu_0 n I_0 \int \omega\, \mathrm{sen}(\omega t) r' dr' d\theta$$

$r<R$ $$E 2\pi r = \mu_0 n I_0 \omega\, \mathrm{sen}(\omega t)\pi r^2$$

$$\vec{E} = \frac{\mu_0 n I_0 \omega\, \mathrm{sen}(\omega t) r}{2}\hat{\theta}$$

$r>R$ $$E 2\pi r = \mu_0 n I_0 \omega\, \mathrm{sen}(\omega t)\pi R^2$$

$$\vec{E} = \frac{\mu_0 n I_0 \omega\, \mathrm{sen}(\omega t) R^2}{2r}\hat{\theta}$$

d) $$u_E = \frac{\varepsilon_0 E^2}{2} = \frac{\mu_0^2 \varepsilon_0 n^2 I_0^2 \omega^2 \mathrm{sen}^2(\omega t) r^2}{8}$$

$$\frac{|B|}{|B_A|} = \frac{4c^2}{\omega^2 r^2}$$

e) $$U_B = \mu_0 n^2 I_0^2 \cos^2(\omega t)\pi R^2 l$$

$$\langle U_B\rangle = \frac{\mu_0 n^2 I_0^2 \pi R^2 l}{4}$$

f) $$U_E = \frac{\mu_0^2 \varepsilon_0 n^2 I_0^2 \omega^2 \mathrm{sen}^2(\omega t)}{8}\int r^2 r\, dr\, d\theta\, dx$$

$$= \frac{\mu_0^2 \varepsilon_0 n^2 I_0^2 \omega^2 \mathrm{sen}^2(\omega t) R^4 2\pi l}{32} = \frac{\mu_0^2 \varepsilon_0 n^2 I_0^2 \mathrm{sen}^2(\omega t) R^4 \pi l\, \omega^2}{16}$$

$$\langle U_E\rangle = \frac{\mu_0^2 \varepsilon_0 n^2 I_0^2 R^4 \pi l\, \omega^2}{32} \qquad \frac{\langle U_E\rangle}{\langle U_B\rangle} = \frac{\omega^2 \mu_0^2 \varepsilon_0 n^2 I_0^2 R^4 \pi l}{32}\,\frac{4}{\mu_0 n^2 I_0^2 \pi R^2 l} = \frac{\omega^2 R^2}{8c^2}$$

g) $\vec{\nabla}\times\vec{B}_A = \mu_0\vec{J} + \mu_0\varepsilon_0\dfrac{\partial \vec{E}}{\partial t}$

$$B_A\, l = \frac{\mu_0^2 \varepsilon_0 n I_0 \omega^2 \cos(\omega t)}{2}\int r' dr' dx \rightarrow \vec{B}_A = \frac{\mu_0^2 \varepsilon_0 n I_0 \omega^2 \cos(\omega t) r^2 \hat{x}}{4} = \frac{\mu_0^2 \varepsilon_0 n I_0 \omega^2 \cos(\omega t) r^2 \hat{x}}{4}$$