4302212 – Física IV

Ondas Eletromagnéticas – III

– Soluções independentes:

$$\frac{\partial E_y}{\partial z} = \frac{\partial B_x}{\partial t}$$

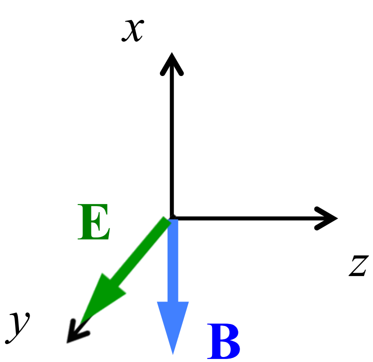
$$\frac{\partial B_x}{\partial z} = \frac{1}{c^2}\frac{\partial E_y}{\partial t}$$

$$\frac{\partial B_y}{\partial z} = -\frac{1}{c^2}\frac{\partial E_x}{\partial t}$$

$$\frac{\partial E_x}{\partial z} = -\frac{\partial B_y}{\partial t}$$

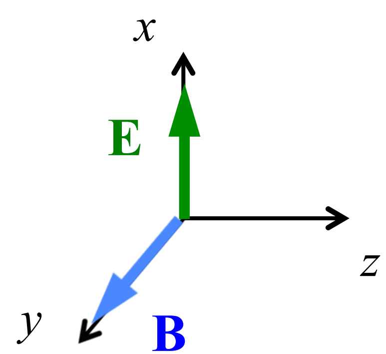
$$\mathbf{E} = E_y(z - ct)\,\hat{\mathbf{y}}$$

$$\mathbf{B} = \frac{1}{c}\hat{\mathbf{z}} \times \mathbf{E}$$



$$\mathbf{E} = E_x(z - ct)\,\hat{\mathbf{x}}$$

$$\mathbf{B} = \frac{1}{c}\hat{\mathbf{z}} \times \mathbf{E}$$



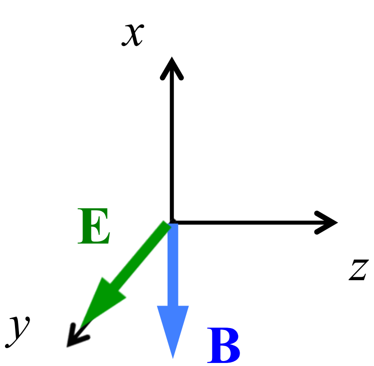
– **Polarização linear**: vetor **E**(z,t) permanece no mesmo plano

– **Direção de Polarização**: $\hat{\epsilon} = \hat{\mathbf{E}}$

– Diferentes polarizações lineares podem ser obtidas dos casos particulares discutidos:

$$\hat{\epsilon} = \hat{\mathbf{y}}$$

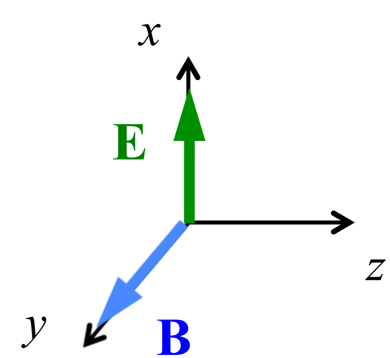
$$\mathbf{E} = E_y(z - ct)\,\hat{\mathbf{y}}$$



$$\mathbf{B} = \frac{1}{c}\hat{\mathbf{z}} \times \mathbf{E}$$

$$\hat{\epsilon} = \hat{\mathbf{x}}$$

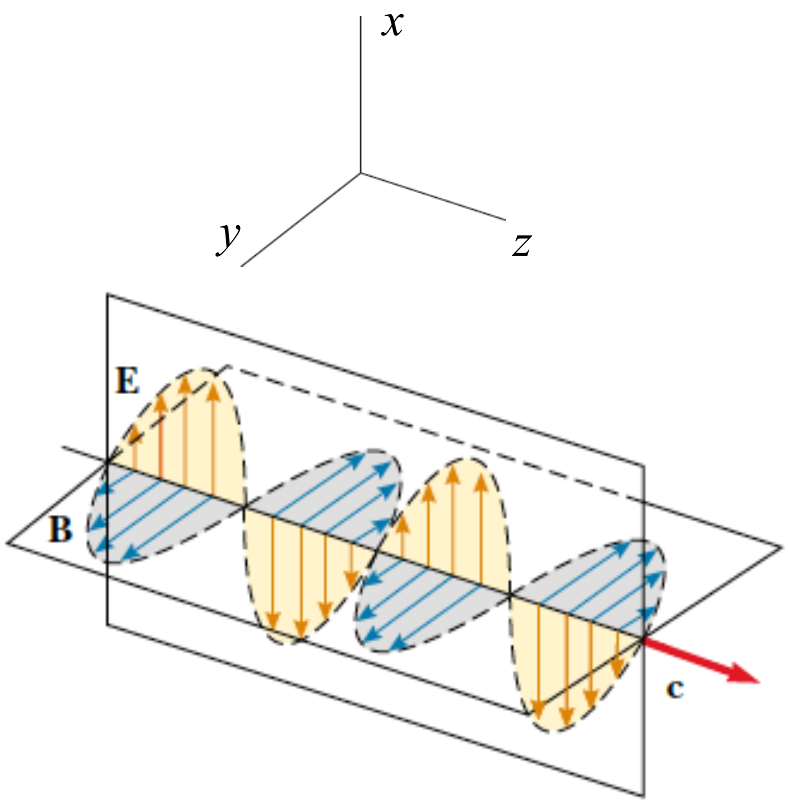
$$\mathbf{E} = E_x(z - ct)\,\hat{\mathbf{x}}$$



Ondas EM Monocromáticas

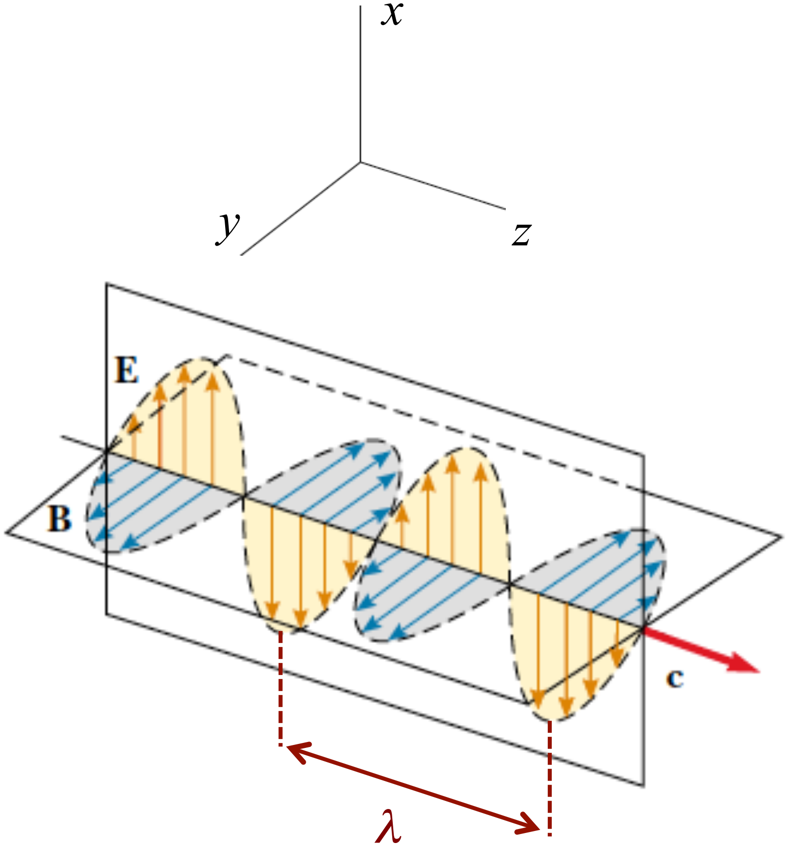
$$E_x(z,t) = E_{\max}\cos[k(z-ct)+\phi] \; = \; E_{\max}\cos(kz-\omega t+\phi)$$

$$\omega \; = \; kc$$



$$B_y = \frac{1}{c}E_{\max}\cos(kz-\omega t+\phi)$$

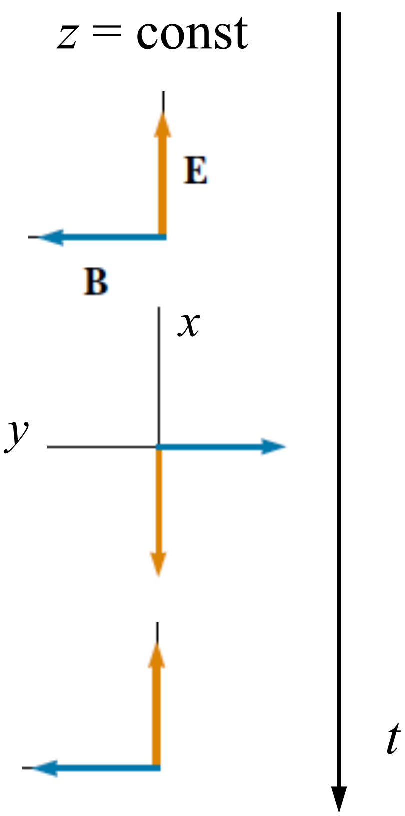
$$= B_{\max}\cos(kz-\omega t+\phi)$$



– Periodicidade espacial:

$$\mathbf{E} = E_{\max}\cos(kz - \omega t + \phi)\ \hat{\mathbf{x}}$$

$$\lambda = \frac{2\pi}{k}$$

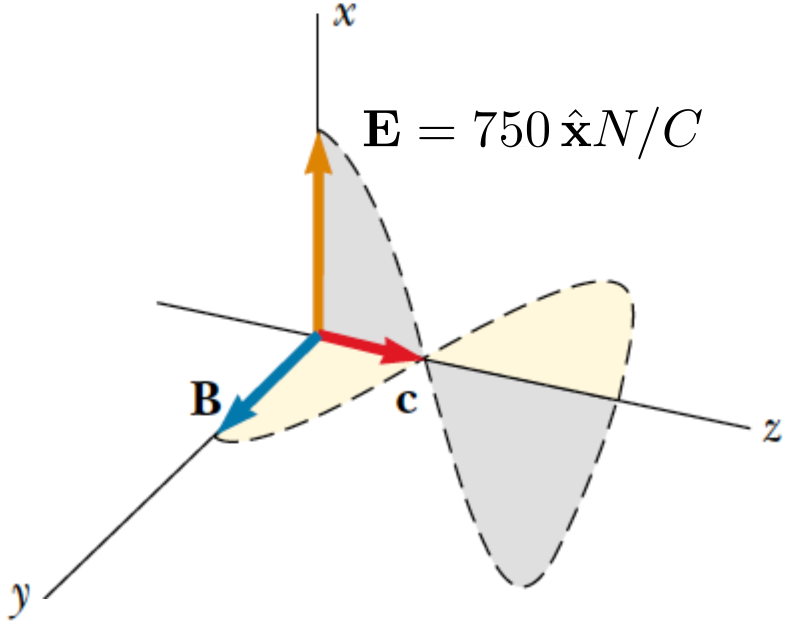


– Periodicidade temporal:

$$\mathbf{E} = E_{\max}\cos(kz - \omega t + \phi)\ \hat{\mathbf{x}}$$

$$T = \frac{2\pi}{\omega}$$

Exercício: Uma onda EM monocromática tem frequência de 40.0 MHz. (a) Determine seu período e comprimento de onda. (b) Em um dado instante e uma dada posição, o campo elétrico tem magnitude de 750 N/C ao longo da direção **x**. Determine a amplitude e direção do campo magnético nas mesmas condições.



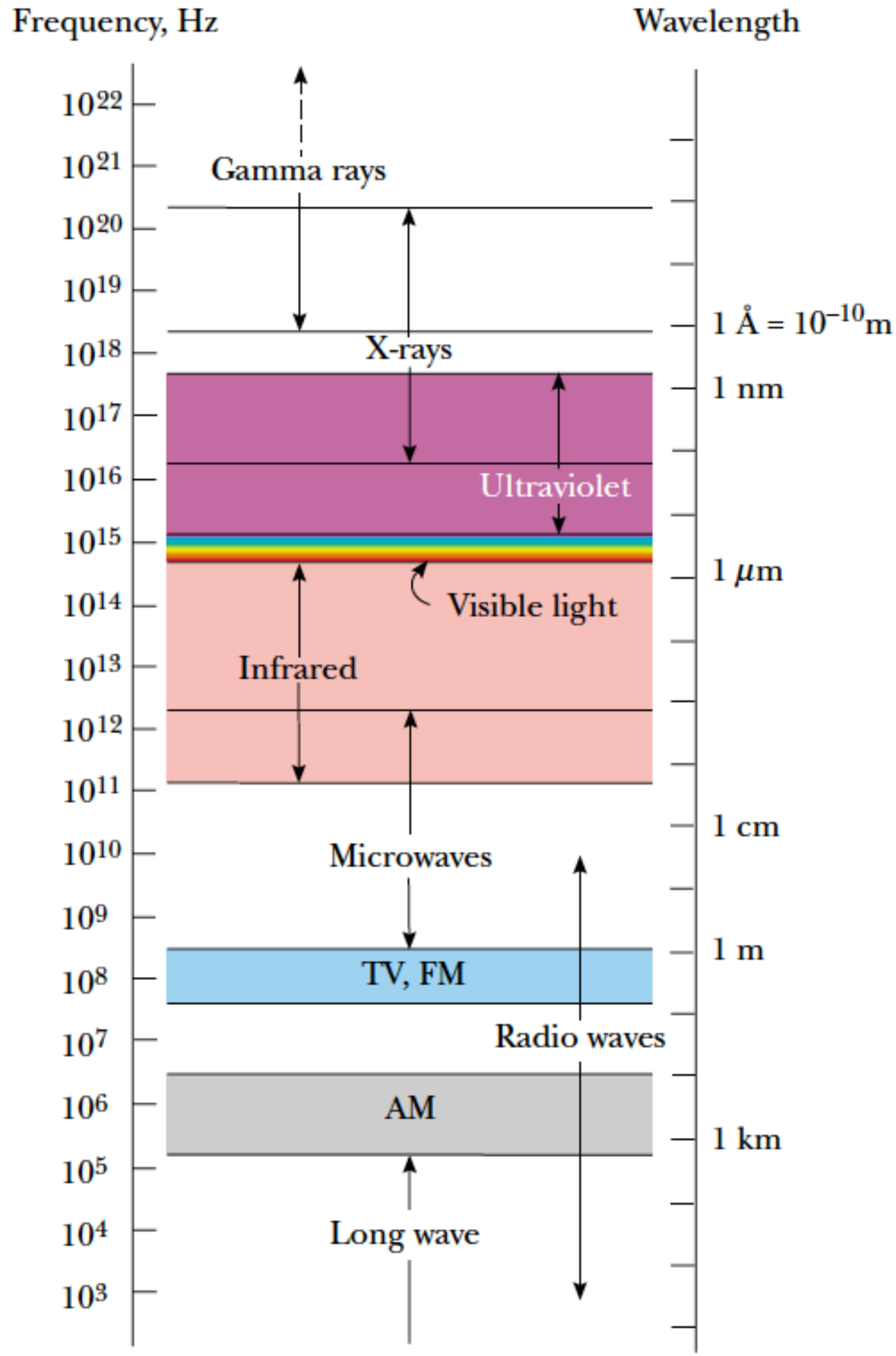
$$\lambda = \frac{c}{f} = \frac{3.00 \times 10^8\ \mathrm{m/s}}{4.00 \times 10^7\ \mathrm{s}^{-1}} = \boxed{7.50\ \mathrm{m}}$$

$$T = \frac{1}{f} = \frac{1}{4.00 \times 10^7\ \mathrm{s}^{-1}} = \boxed{2.50 \times 10^{-8}\ \mathrm{s}}$$

$$B_{\mathrm{max}} = \frac{E_{\mathrm{max}}}{c} = \frac{750\ \mathrm{N/C}}{3.00 \times 10^8\ \mathrm{m/s}} = \boxed{2.50 \times 10^{-6}\ \mathrm{T}}$$

$$\hat{\mathbf{B}} = \hat{\mathbf{z}} \times \hat{\mathbf{E}}$$

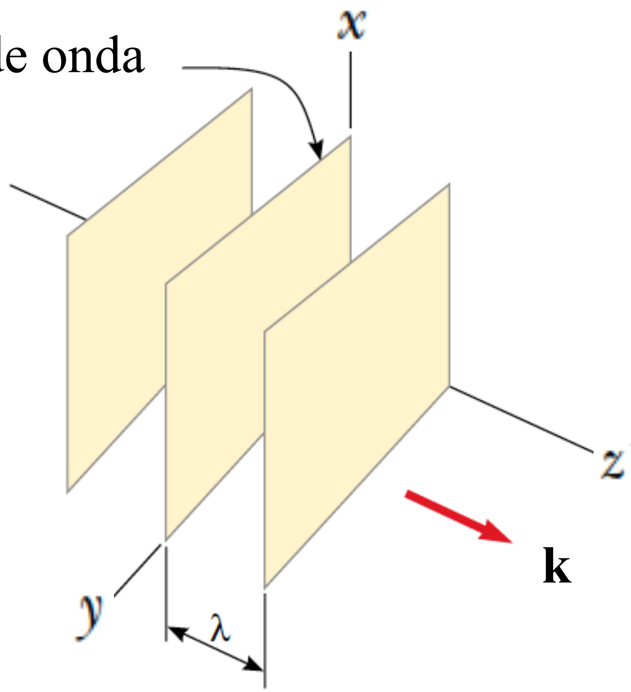
Espectro das Ondas EM



Ondas EM Planas

– As soluções discutidas constituem ondas EM linearmente polarizadas, monocromáticas e **planas**:

$$\mathbf{k} = k\hat{\mathbf{z}} \qquad\qquad \mathbf{E} = E_{\max}\cos(\mathbf{k}\cdot\mathbf{r} - \omega t + \phi)\,\hat{\mathbf{x}}$$



Experimento de Hertz (1887)

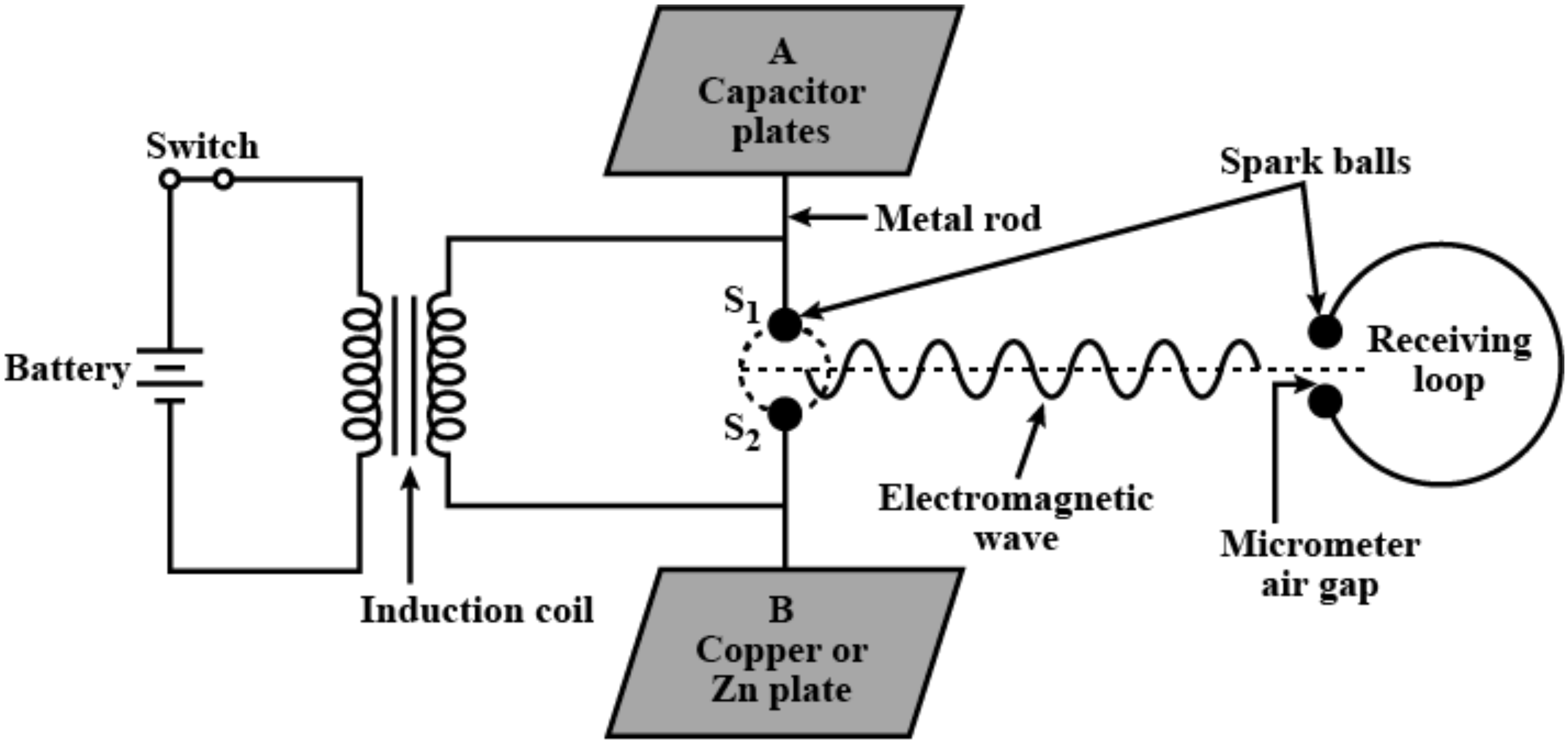
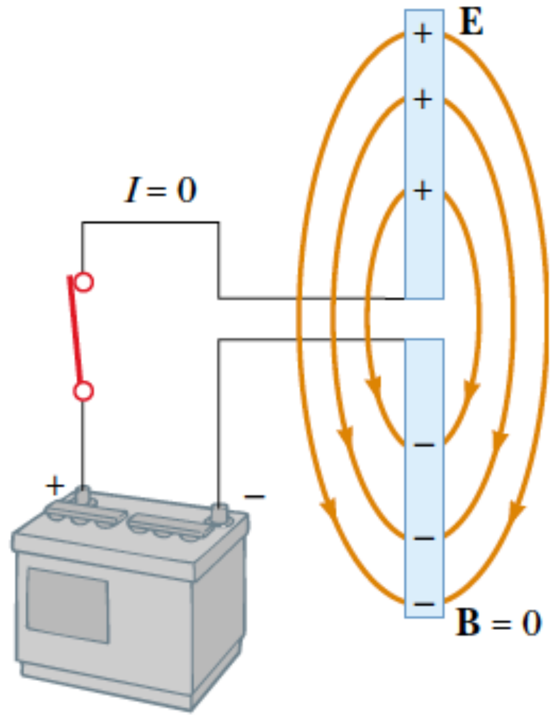


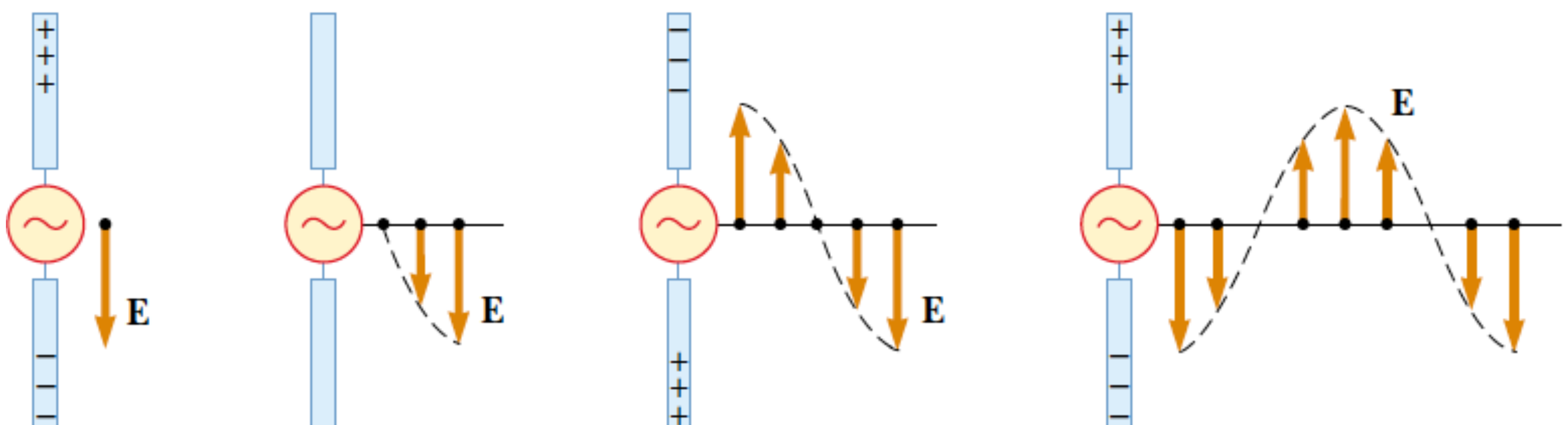
Fig : Sketch of the apparatus used by Hertz for producingand detecting radiowaves

imagem: https://www.toppr.com/ask/question/explain-the-hertzs-experiment-of-related-to-electromagnetic-wave/

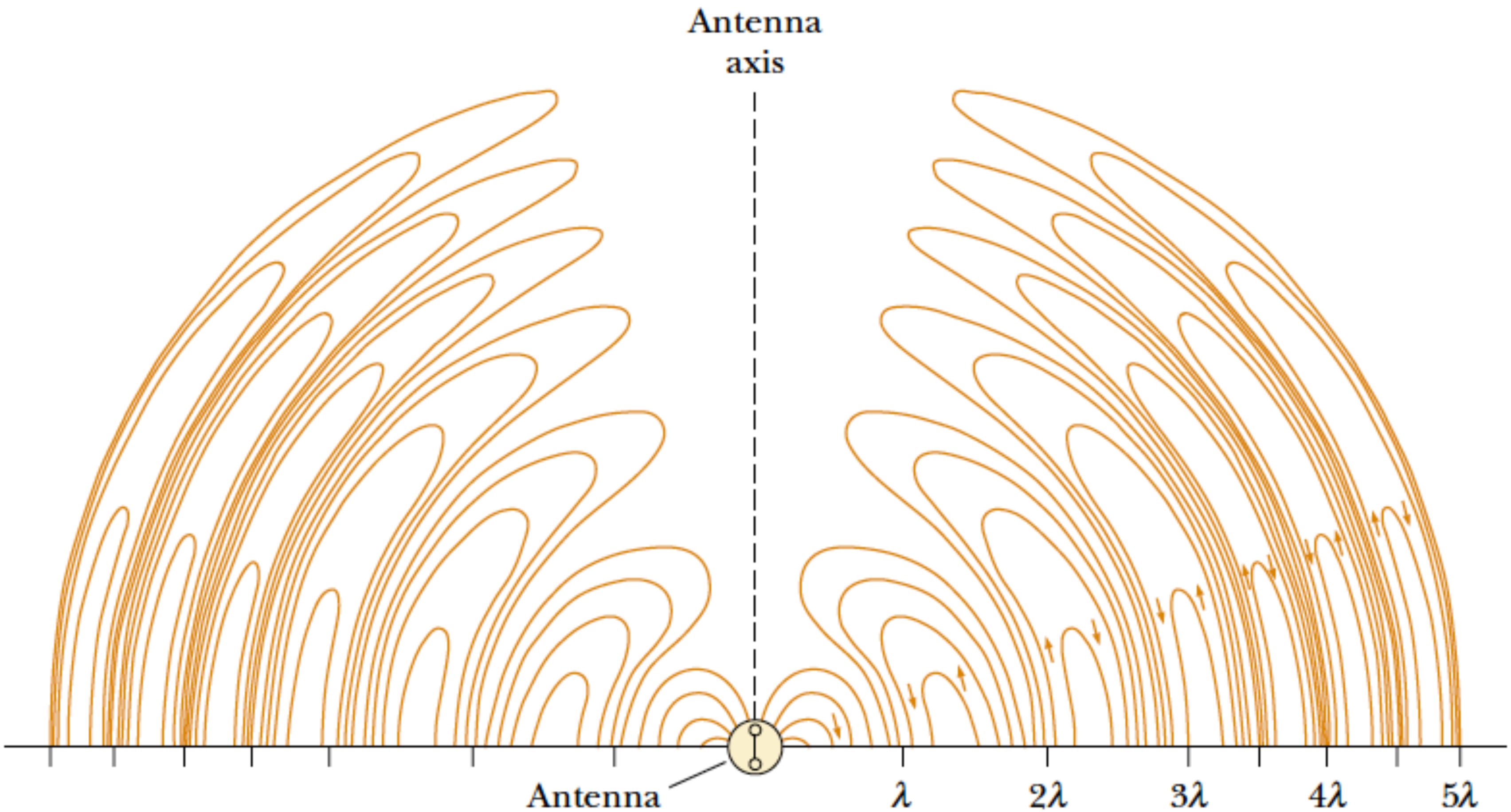
vídeo: https://www.youtube.com/watch?v=9gDFll6Ge7g&t=173s



Radiação de Dipolo



(a) $t = 0$ (b) $t = \frac{T}{4}$ (c) $t = \frac{T}{2}$ (d) $t = T$



vídeo: https://www.youtube.com/results?search_query=dipole+radiation+kink+generation