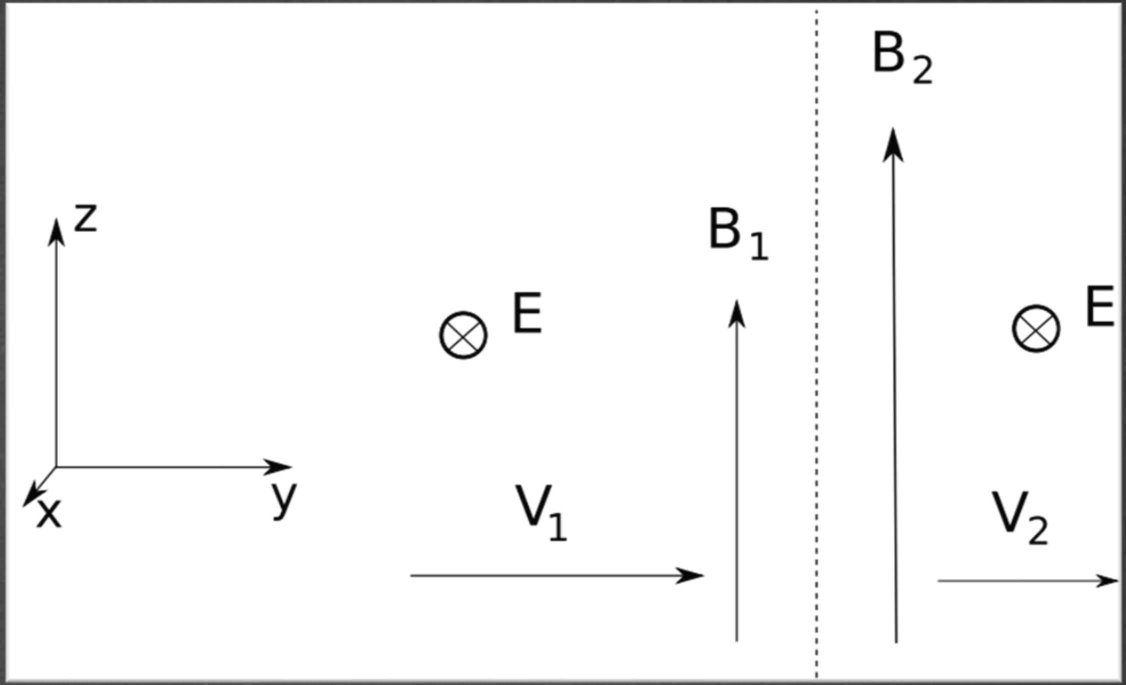
$$\boldsymbol{F} = q(\boldsymbol{v} \times \boldsymbol{B} + \mathbf{E}) \quad \mathbf{B} = B_0\, \boldsymbol{z} \quad \mathbf{E} = -E_0\, \boldsymbol{x}$$



$$\boldsymbol{v} \times \boldsymbol{B} = \begin{vmatrix} \boldsymbol{x} & \boldsymbol{y} & \boldsymbol{z} \\ v_x & v_y & v_z \\ 0 & 0 & B_0 \end{vmatrix} = \boldsymbol{x}(B_0 v_y) - \boldsymbol{y}(v_x B_0)$$

$$\boldsymbol{F} = q\left[\boldsymbol{x}(B_0 v_y - E_0) - \boldsymbol{y}(B_0 v_x)\right]$$

$$\mathrm{m}\left(\frac{dv_x}{dt}\boldsymbol{x} + \frac{dv_y}{dt}\boldsymbol{y} + \frac{dv_z}{dt}\boldsymbol{z}\right) = q\left[\boldsymbol{x}(B_0 v_y - E_0) - \boldsymbol{y}(B_0 v_x)\right]$$

$$\begin{cases} \mathrm{m}\dfrac{dv_x}{dt} = q(B_0 v_y - E_0) \\ \mathrm{m}\dfrac{dv_y}{dt} = -qB_0 v_x \\ \mathrm{m}\dfrac{dv_z}{dt} = 0 \end{cases} \xrightarrow{\omega = \frac{qB_0}{m}} \quad \begin{aligned} &\frac{dv_x}{dt} = \omega\left(v_y - \frac{E_0}{B_0}\right) \quad (I) \\ &\frac{dv_y}{dt} = -\omega v_x \quad (II) \end{aligned}$$

Derivando a (II) e substituindo na (I)

$$\frac{d^2 v_y}{dt^2} = -\omega \frac{dv_x}{dt} = -\omega^2 \left(v_y - \frac{E_0}{B_0} \right) = \omega^2 \left(\frac{E_0}{B_0} - v_y \right)$$

$$\frac{d^2 v_y}{dt^2} = \omega^2 \left(\frac{E_0}{B_0} - v_y \right) \longrightarrow \frac{d^2 v_y}{dt^2} + \omega^2 v_y = \omega^2 \frac{E_0}{B_0}$$

Equação diferencial não homogênea de 2° ordem

→ *Solução homogênea*$(y_h(t))$

$$\lambda^2 + \omega^2 = 0$$

$$\lambda^2 = -\omega^2$$

$$\lambda = \pm i\omega$$

$$y_h(t) = e^{\alpha t}(A_1 \cos \beta t + A_2 \sin \beta t)$$

Sendo um número complexo $c = \alpha + \beta i$

$$y_h(t) = A_1 \cos \omega t + A_2 \sin \omega t$$

$\longrightarrow$ *Solução particular* $\left(\mathrm{y_p(t)}\right)$

$$y_p(t) = A_3 \longrightarrow \frac{dy_p}{dt} = \frac{d^2y_p}{dt^2} = 0$$

$$\omega^2 A_3 = \omega^2 \frac{E_0}{B_0} \longrightarrow A_3 = \frac{\mathrm{E_0}}{\mathrm{B_0}} \longrightarrow y_p(t) = \frac{E_0}{B_0}$$

$\longrightarrow$ *Solução geral* $\left(\mathrm{y(t) = y_p(t) + y_h(t)}\right)$

$$v_y(\mathrm{t}) = A_1 \cos\omega t + A_2 \sin\omega t + \frac{E_0}{B_0} \longrightarrow v_y(0) = v_0 = \mathrm{A_1} + \frac{\mathrm{E_0}}{\mathrm{B_0}} \longrightarrow \mathrm{A_1} = v_0 - \frac{\mathrm{E_0}}{\mathrm{B_0}}$$

$$\int_0^t v_y(\mathrm{t})\,\mathrm{dt} = y(t) - y(0) = \int_0^t \left(A_1 \cos\omega t + A_2 \sin\omega t + \frac{E_0}{B_0}\right) dt = \left\{\frac{1}{\omega}\left[\left(v_0 - \frac{E_0}{B_0}\right)\sin\omega t - \mathrm{A_2}\cos\omega t\right] + \frac{E_0}{B_0}\right\}\Bigg|_0^t$$

$$\int_0^t v_y(\mathrm{t})\,\mathrm{dt} = y(t) - y(0) = \int_0^t \left(A_1 \cos\omega t + A_2 \sin\omega t + \frac{E_0}{B_0} \right) dt = \left\{ \frac{1}{\omega} \left[\left(v_0 - \frac{E_0}{B_0} \right) \sin\omega t - \mathrm{A}_2 \cos\omega t \right] + \frac{E_0}{B_0} \right\} \Bigg|_0^t$$

$$y(t) - y(0) = \frac{1}{\omega} \left(v_0 - \frac{E_0}{B_0} \right) \sin\omega t - \mathrm{A}_2 \left[\frac{1}{\omega} (\cos\omega t + 1) \right] + \frac{\mathrm{E}_0}{\mathrm{B}_0} \mathrm{t}$$

$$Para\ t = 0 \longrightarrow A_2 = 0$$

$$v_y(\mathrm{t}) = \left(v_0 - \frac{\mathrm{E}_0}{\mathrm{B}_0} \right) \cos\omega t + \frac{E_0}{B_0} \longrightarrow y(t) = y(0) + \frac{1}{\omega} \left(v_0 - \frac{E_0}{B_0} \right) \sin\omega t + \frac{E_0}{B_0} t$$

Substituindo v_y na equação (I), sendo $v_x(0) = 0$.

$$\frac{dv_x}{dt} = \omega \left(v_y - \frac{E_0}{B_0} \right) = \omega \left(v_0 - \frac{E_0}{B_0} \right) \cos\omega t \longrightarrow v_x(t) = \left(v_0 - \frac{E_0}{B_0} \right) \sin\omega t$$

$$v_x(t) = \left(v_0 - \frac{E_0}{B_0}\right)\sin\omega t \xrightarrow{\textit{Integrando}} x(t) = x(0) - \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)(\cos\omega t + 1)$$

$$y(t) - y(0) = \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)\sin\omega t + \frac{E_0}{B_0}t$$

$$y(t) - \left[y(0) + \frac{E_0}{B_0}t\right] = \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)\sin\omega t$$

$$x(t) - \left[x(0) - \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)\right] = -\frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)\cos\omega t$$

$$R_T = \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)$$

$$\omega = \frac{qB_0}{m}$$

$$[x(t) - \overbrace{(x(0) - R_t)}^{\textit{Constante}}]^2 + \left[y(t) - \left(y(0) + \frac{E_0}{B_0}t\right)\right]^2 = R_t^2$$

$$y(t) - \left[y(0) + \frac{E_0}{B_0}t\right] = \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)\sin\omega t$$

$$x(t) - \left[x(0) - \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)\right] = -\frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)\cos\omega t$$

$$R_T = \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)$$

$$\omega = \frac{qB_0}{m}$$

Periodo de funções senos e cossenos

$$Periodo = \frac{2\pi}{\omega} = \mathrm{t_p}$$

$$y_p(t_p) = y(0) + \frac{E_0}{B_0}t_p = 0 + \frac{2\pi E_0}{\omega B_0} =$$

```
print('{:.3e}'.format(y_p))
1.111e+06
```

$$\frac{y_p(t_p)}{\mathrm{R1}} =$$

```
round((y_p/R1),3)
7.795
```

$$y(t) - \left[y(0) + \frac{E_0}{B_0}t\right] = \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)\sin\omega t$$

$$x(t) - \left[x(0) - \frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)\right] = -\frac{1}{\omega}\left(v_0 - \frac{E_0}{B_0}\right)$$

Periodo de funções senos e cossenos

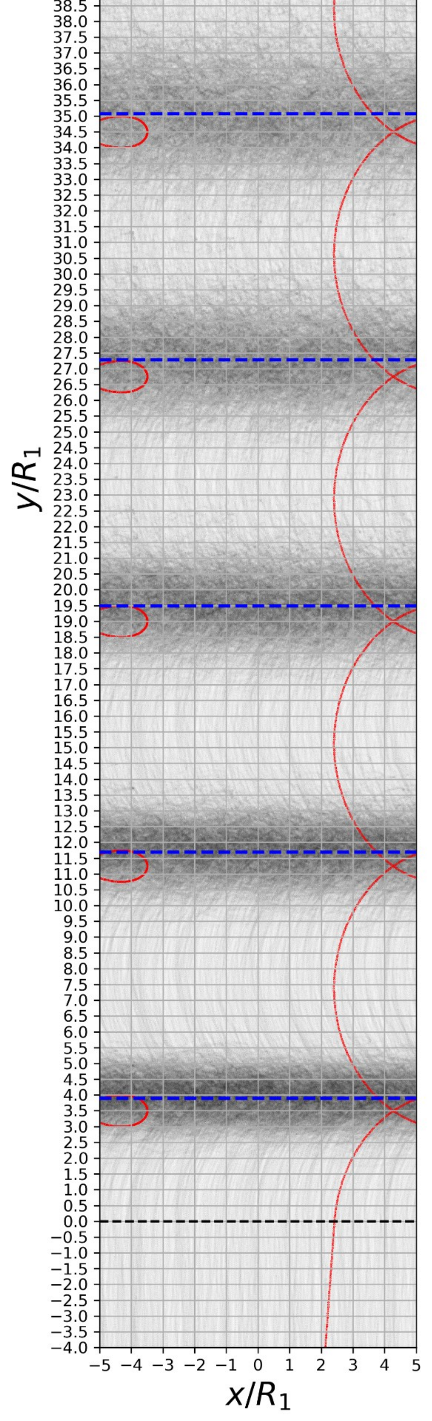
$$Periodo = \frac{2\pi}{\omega} = \mathrm{t_p}$$

$$y_p(t_p) = y(0) + \frac{E_0}{B_0}t_p = 0 + \frac{2\pi E_0}{\omega B_0} =$$

```
print('{:.3e}'
```

```
1.111e+06
```

$$\frac{y_p(t_p)}{\mathrm{R1}} =$$



$R_T =$

$\omega =$