$$\begin{vmatrix} & \hat{} & \hat{z} \\ j_r & 0 & j_z \\ 0 & B_\theta & 0 \end{vmatrix} = j_r B_\theta \hat{z}$$

1D MPD Flow & Induced $\vec{B}$ field

only: (Scalar σ)

$$\frac{\partial \rho}{\partial t} + \vec{\nabla}\cdot(\rho \vec{u}) = 0$$

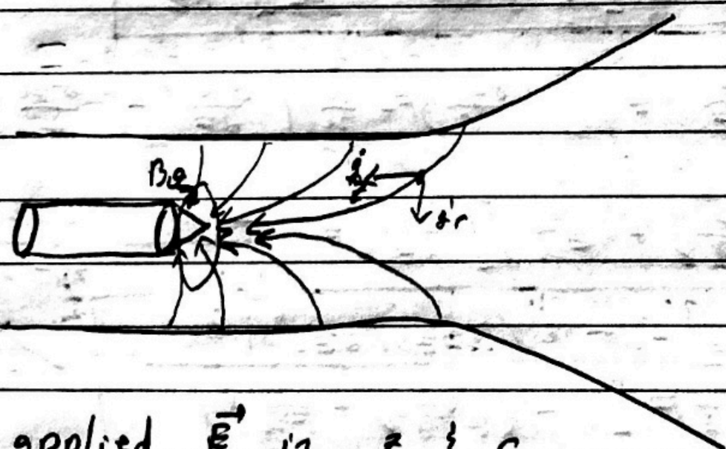
$$\rho\left(\frac{\partial \vec{u}}{\partial t} + \vec{u}\cdot\vec{\nabla}\vec{u}\right) = -\vec{\nabla}p + \vec{j}\times\vec{B}$$

$$\rho\left(\frac{\partial}{\partial t} + \vec{u}\cdot\vec{\nabla}\right)\left(c_p T + \frac{u^2}{2}\right) = \frac{\partial p}{\partial t} + \vec{j}\cdot\vec{E}$$

$$\vec{j} = \sigma(\vec{E} + \vec{u}\times\vec{B})$$

$$\vec{\nabla}\times\vec{E} = \frac{\partial \vec{B}}{\partial t} \quad ; \quad \vec{\nabla}\times\vec{B} = \mu_0 \vec{j} \quad ; \quad \vec{\nabla}\cdot\vec{B} = 0$$

$\rightarrow$



$\rightarrow$ applied $\vec{E}$ in z & r

$\hookrightarrow \vec{j} = j_r \hat{r} + j_z \hat{z}$

$\rightarrow$ induced $\vec{B} = B_\theta \hat{\theta}$

$\rightarrow$ consider 1D steady state flow

$\vec{\nabla} \rightarrow \frac{\partial}{\partial z}\hat{z}$; $\vec{u} = u\hat{z}$

$\Rightarrow \vec{\nabla}\times\vec{E} = 0$; $\vec{\nabla}\cdot\vec{B} = 0$

$$\vec{\nabla}\times\vec{B} = \begin{vmatrix} \hat{r} & \hat{\theta} & \hat{z} \\ 0 & 0 & \partial/\partial z \\ 0 & B_\theta & 0 \end{vmatrix} = -\frac{\partial B_\theta}{\partial z}\hat{z} = -\frac{dB_\theta}{dz}\hat{r} = \mu_0 j_r$$