Magnetic flux density

$$\partial_t B \;=\; -\nabla\times E, \quad \nabla\cdot B \;=\; 0 \tag{1}$$

Magnetic field strength and Ohm's Law

$$\nabla\times H \;=\; J \;=\; \sigma\,(E \;+\; u\times B) \tag{2}$$

For a magnetic material

$$E \;=\; -u\times B \;+\; \frac{1}{\sigma}\nabla\times H, \qquad H \;=\; \frac{1}{\mu}B \tag{3}$$

Therefore, the Induction equation

$$\partial_t B \;=\; \nabla\times\left(u\times B \;-\; \frac{1}{\sigma}\nabla\times\frac{B}{\mu}\right) \tag{4}$$

We can use a vector potential

$$B \;=\; \nabla\times A, \qquad \partial_t A \;+\; \nabla\phi \;=\; u\times B \;-\; \frac{1}{\sigma}\nabla\times\frac{B}{\mu} \tag{5}$$

In the Column gauge $\nabla\cdot A \;=\; 0$.

$$\text{In 2D} \qquad B \;=\; \nabla\times(A\hat{z}), \qquad \nabla\times\frac{\nabla\times(A\hat{z})}{\mu} \;=\; -\nabla\cdot\left(\frac{1}{\mu}\nabla A\right)\hat{z} \tag{6}$$

$$\partial_t A \;+\; u\cdot\nabla A \;=\; \sigma^{-1}\nabla\cdot\left(\mu^{-1}\nabla A\right) \tag{7}$$

The Lorenz force

$$\mathcal{F} \;=\; J\times B \;=\; (\nabla\times H)\times B \tag{8}$$

The Maxwell stress

$$\Sigma \;\equiv\; \frac{1}{\mu}\left[B\,B - \frac{|B|^2}{2}\,I\right] \tag{9}$$

$$\mathcal{F} \;=\; \nabla\cdot\Sigma \;+\; \frac{|B|^2}{2\mu}\,\nabla\log\mu \tag{10}$$