Connections between J, B and A

$$\vec{J} \quad \rightarrow \quad A = \frac{\mu_0}{4\pi}\int \frac{\vec{J}(\vec{r}_i)}{|\vec{r}_{ip}|} d\tau_i$$

$$\nabla^2 \vec{A} = -\mu_0 \vec{J} \quad \leftarrow \quad \vec{A}$$

$$\vec{J} \quad \rightarrow \quad \vec{B} = \frac{\mu_0}{4\pi}\int \frac{\vec{J}\times\vec{r}_{ip}}{|\vec{r}_{ip}|^3} d\tau_i$$

$$\vec{\nabla}\times\vec{B} = \mu_0\vec{J}; \vec{\nabla}\bullet\vec{B} = 0 \quad \leftarrow \quad \vec{B}$$

$$\vec{A} \quad \rightarrow \quad \vec{B} = \vec{\nabla}\times\vec{A}; \vec{\nabla}\bullet\vec{A} = 0$$

$$\vec{B} = \vec{\nabla}\times\vec{A}; \vec{\nabla}\bullet\vec{A} = 0 \quad \leftarrow \quad \vec{B}$$

Without derivation, I want to provide you with the boundary conditions on B and A when crossing a surface current density $\vec{K}$.

$$\begin{matrix} B^{\perp}_{above} = B^{\perp}_{below} \\ B^{\parallel}_{above} - B^{\parallel}_{below} = \mu_0 K \end{matrix} \Rightarrow \vec{B}_{above} - \vec{B}_{below} = \mu_0\left(\vec{K}\times\hat{n}\right)$$

For A we have:

$$\vec{A}_{above} = \vec{A}_{below}$$

$$\frac{\partial\vec{A}_{above}}{\partial n} - \frac{\partial\vec{A}_{below}}{\partial n} = -\mu_0\vec{K}$$

There is much that we will be omitting by now going on to Faraday's law.