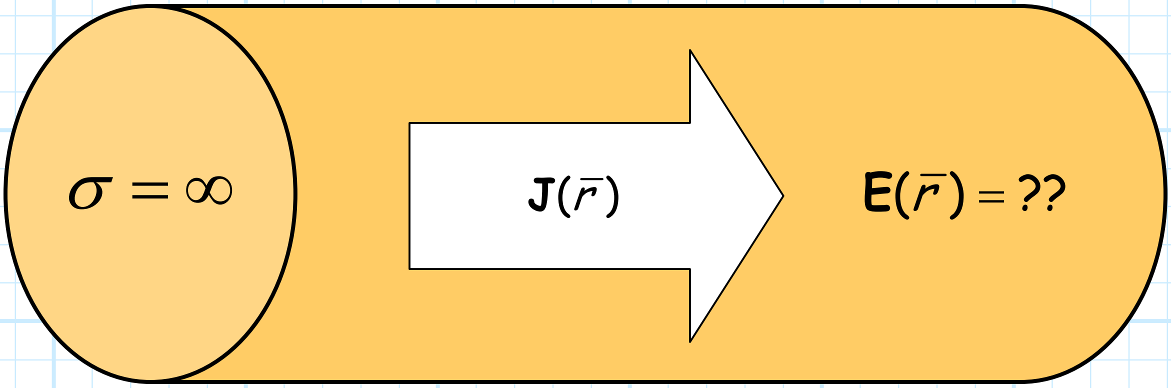
Perfect Conductors

Consider now some current with density $\mathbf{J}(\bar{r})$, flowing within some material with **perfect conductivity** (i.e., $\sigma = \infty$)!



Q: *What is the **electric field** $\mathbf{E}(\bar{r})$ within this perfectly conducting material?*

A: Well, we know from **Ohm's Law** that the electric field is to the material conductivity and current density as:

$$\mathbf{E}(\bar{r}) = \frac{\mathbf{J}(\bar{r})}{\sigma}$$

Thus, as the material conductivity approaches **infinity**, we find:

$$\lim_{\sigma \to \infty} \mathbf{E}(\bar{r}) = \frac{\mathbf{J}(\bar{r})}{\sigma} = 0$$

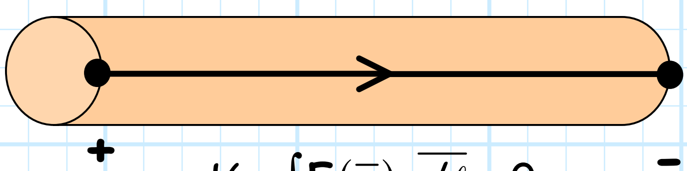
The **electric field** in within a perfectly conducting material is always equal to **zero**!

This makes since when you think about it! Since the material offers **no resistance**, we can move charges through it **without** having to apply any **force** (i.e., and electric field).

This is just like a skater moving across ***frictionless*** *ice! I can continue to move with great velocity, even though* ***no force*** *is being applied!*

Consider what this means with regards to a **wire** made of a **perfectly conducting** material (an often applied assumption).

The electric potential difference between either end of a perfectly conducting wire is **zero**!



$$V = \int_C \mathbf{E}(\bar{r}) \cdot \overline{d\ell} = 0$$

Since the electric field within a perfect wire is **zero**, the voltage across any perfect wire is also **zero**, regardless of the current flowing through it.