

18.4 Let us demonstrate, by appropriate substitution and algebraic manipulation, that Equation 18.5 may be made to take the form of Equation 18.1. Now, Equation 18.5 is just

$$J = \sigma E$$

(In this equation we represent the electric field with an “ E ”.) But, by definition, J is just the current density, the current per unit cross-sectional area, or $J = \frac{I}{A}$. Also, the electric field is defined by $E = \frac{V}{l}$. And, substituting these expressions into Equation 18.5 leads to

$$\frac{I}{A} = \sigma \frac{V}{l}$$

But, from Equations 18.2 and 18.4

$$\sigma = \frac{l}{RA}$$

and

$$\frac{I}{A} = \left(\frac{l}{RA} \right) \left(\frac{V}{l} \right)$$

Solving for V from this expression gives $V = IR$, which is just Equation 18.1.