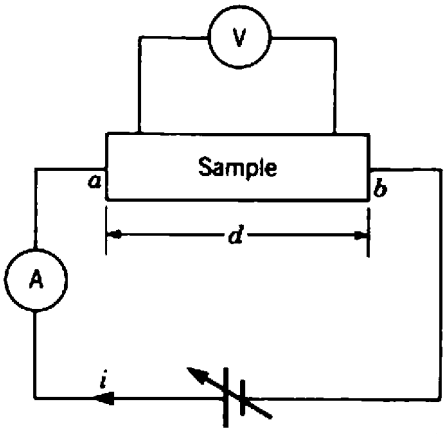
Free Electron Theories of Solids

According to Ohm's law,

$$V = iR \tag{1}$$

where V, i, and R represent voltage, current, and resistance respectively.



Ohm's law can be restated in a form more appropriate to the understanding of the phenomenon of conduction by concentrating attention on a sample conductor. The fact that there is a potential difference V across the sample means that there is an electric field E in the sample. If the sample is uniform in geometry and quality, E will be constant, and it follows that

$$V = E\,d \tag{2}$$

where d is the length of the sample.

Given a certain potential difference (and therefore a certain E), the larger the cross-sectional area A of the sample , the larger the current will be. Let us introduce a new quantity, the current density J, defined as the current per unit cross-sectional area .

$$J = \frac{i}{A} \quad \text{or} \quad i = J\,A \tag{3}$$

Therefore Ohm's law ($V = i\,R$) becomes,

$$Ed = JA\,R \quad \text{or} \quad E = R\frac{A}{d}\,J$$

$$E = \rho\,J \tag{4}$$

where the quantity $\rho = RA/d$ is called the *electrical resistivity*. Equation (4) can be written as

$$J = \sigma\,E \tag{5}$$

where $\sigma = 1/\rho$ and is called *electrical conductivity*.