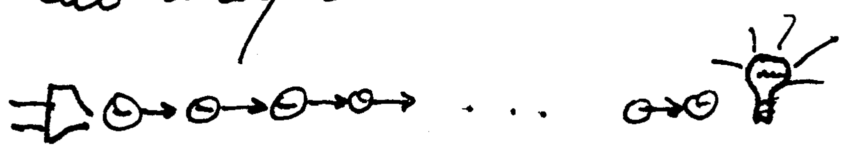
How then do we see lights go on almost immediately when we plug them in

2m lamp cord (~6') would take

$$t = \frac{d}{v} = \frac{2\,m}{2\times10^{-4}\,m} = 10^4\,s$$ or

about 25m for electron to travel from plug to lamp. But that's not the way it works



RESISTIVITY

$\vec{E}$ field produces the force on the charges causing them to move thus $\vec{E}$ determines $\vec{v}$, other variables depend only on characteristics of the mat'l in question (eg. # of free electrons per m^3 etc) In general relationship between $\vec{E}$ + $\vec{v}$ is quite complex, but for certain class of mat'ls (notably the metals) the relationship is very nearly linear

$$\vec{v} \propto \vec{E}$$

$J \propto E$

$$\boxed{\vec{J} = \sigma \vec{E}}$$ σ - conductivity

or

$$\boxed{\vec{E} = \rho \vec{J}}$$ $\rho = \frac{1}{\sigma} =$ resistivity

where ρ, σ are purely characteristics of the mat'l in question

$\rho \to 0$ perfect conductor
$\rho \to \infty$ perfect insulator

Metals
$10^{-8} \lesssim \rho \lesssim 10^{-7}$
Silver → Copper
higher ρ but cheaper

Alloys
$\rho \approx 10^{-6}$
Nichrome
Current flows but ρ high
lots of coll'n

Insulators
$10^{8} - 10^{18}$
Wood - ~~fused~~ Quartz

Semiconductors
$10^{-5} - 10^{3}$
C - Si

G.S. Ohm discovered that at given T ρ is constant for given metal over wide range of E. There is some variation w/ T. Can represent by

$$\rho(T) = \rho_0 \left[1 + \alpha (T - T_0)\right]$$

where α typically $10^{-4} - 5\times10^{-3}$ very small