Q1- During the time interval between t = 0 and t = 17 s, the total charge that crossed a plane across a wire at time t is given by $(16\,C)(1 - e^{-t/5.8s})$, where t is in seconds. What is the maximum value of the current? What is the current at t = 5.8 s?

The current is the rate of flow of charge and hence if the total charge crossed is Q at time t and Q + dQ at time t + dt then the current at time t is given by

$$I = \frac{dQ}{dt} = \frac{d}{dt}\left[16\left(1 - e^{-t/5.8}\right)\right]$$

Or $$I = 16\left[0 - e^{-t/5.8}\left(-\frac{1}{5.8}\right)\right]$$

Or $$I = 16 * e^{-t/5.8}\left(\frac{1}{5.8}\right)$$

Or $$I = 2.76 * e^{-t/5.8}$$

Here the current is a function of time and decreasing continuously with it. The current will be maximum for t = 0 and minimum for T = infinity.

The maximum current is

$$I_{max} = 2.76*e^{0} = 2.76\text{ A}$$

And the current at time 5.8 sec will be

$$I = 2.76 * e^{-5.8/5.8} = \frac{2.76}{e} = \frac{2.76}{2.72} = 1.015\,A$$

[This equation is the same as the equation for the charging of a capacitor and the behavior is similar to that. The charge is 0 at t = 0 and the charging current is maximum at t = infinity]

Q2- A tube of mercury with a resistivity of $9.84x10^{-7}\,\Omega.m$ has a 17.0 N/C electric field inside the column of mercury. How much current is flowing, if the diameter of the tube is 2.0 mm?

The current density is given by

$$j = E/\rho$$

Here E is electric field and ρ is resistivity of the conductor.

Or $$j = \frac{17.0}{9.84*10^{-7}} = 1.73*10^{7}\,A/m^{2}$$

Hence current through the column is

$$I = j*A = j*\pi d^2/4 = 1.73*10^{7}*3.14*(2.0*10^{-3})^{2}/4 = 54.32\text{ A}.$$
