Fundamentals of Physics in Engineering I

Unit 7.- ELECTRIC CURRENT

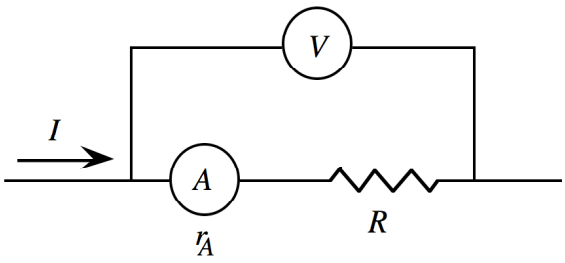
1.- A copper wire, with a circular cross section of 1 cm of diameter, carries a current of 100 A. Copper has 8.5 x 10^{22} free electrons per cm^3 and its resistivity at ambient temperature is 1.72 x 10^{-8} Ω·m. Calculate: (a) The current density in the wire in A/m^2. (b) The drift velocity of the free electrons. (c) The value of the electric field inside the wire.

2.- Find the density of free electrons n for a copper wire if there is a free electron for each copper atom. If the maximum recommended current for a copper wire of 0.81 mm of radius (as the ones used domestically) is 15 A, what is the drift velocity of the electrons in the wire?

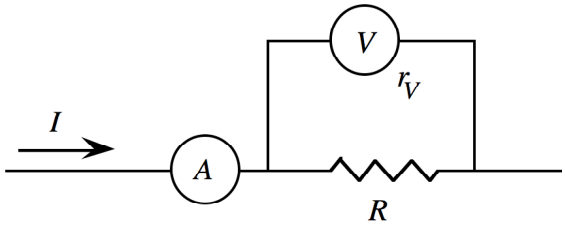
3.-A copper wire has a circular section of 1.02 mm of diameter and carries a current of 1.67 A. The resistivity is 1.72 x 10^{-8} Ω·m at a temperature of 20ºC. Calculate, at 20°C: (a) The electric field inside the wire. (b) The potential difference between two points separated 50 m along the wire. (c) The resistance of a copper wire with a length of 50 m. (d) The resistance at 0°C and 100°C, if the temperature coefficient of resistivity of copper is $\alpha = 0.00393\ (°C)^{-1}$.

4.-Two identical resistors are connected in series to a potential difference of V. Later on, the two resistors are connected in parallel to the same potential difference V. Which one of the two set-ups dissipates more power?

5.-An ammeter with resistance r_A is connected in series with a resistor, whose resistance R we want to measure, and a voltmeter is connected in parallel with the set, as can be seen in the figure. (a) Calculate R as a function of the values I_m and V_m measured by the ammeter and the voltmeter, respectively. (b) Calculate R when $V_m/I_m >> r_A$. (c) If V_m = 23 V, I_m = 62 mA and r_A = 14 Ω, which is the value of R?



6.-A voltmeter with resistance r_V is connected in parallel with a resistor, whose resistance R we want to measure, and an ammeter is connected in series with the set, as can be seen in the figure. (a) Calculate R as a function of the values I_m and V_m measured by the ammeter and the voltmeter, respectively. (b) Calculate R when $V_m/I_m << r_V$. (c) If V_m = 43 V, I_m = 16 mA and r_V = 62 MΩ, which is the value of R?



7.-*Dynamic resistance*, $R_{din} = dV/dI$, is a useful concept when non-ohmic circuit components are studied. For a diode, a simple model for the *pn* junction behaviour predicts a current-voltage relationship in the form $I(V) = I_0[\exp(eV/kT) - 1]$, where I_0 is the saturation current, different for each diode, k is the Boltzmann's constant, T is the absolute temperature and e is the electron charge. Obtain an expression for the dynamic resistance of this device.

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