Answer on Question 61342, Physics, Electromagnetism

Question:

11) The current I in a conductor as a function of time t is given as $I(t) = 5t^2 - 3t + 10$, where current is in ampres (A) and t is in seconds (s). What quantity of charge moves across a section through the conductor during the interval $t = 2\ s$ to $t = 5\ s$?

a) $154.4\ C$

b) $193.5\ C$

c) $225.5\ C$

d) $300.0\ C$

Solution:

Let's recall the definition of the current. The electric current is the rate at which the electric charge flows through the cross-sectional area of a conductor:

$$I = \frac{\Delta Q}{\Delta t},$$

here, ΔQ is the amount of charge that passes through the cross-sectional area of the conductor in a time interval Δt.

Let's write the definition of the electric current in the differential form:

$$I = \frac{dQ}{dt}.$$

From this formula, we can find the quantity of charge moves across a section through the conductor during the interval from $t = 2\ s$ to $t = 5\ s$:

$$dQ = Idt,$$

$$Q = \int_2^5 Idt = \int_2^5 (5t^2 - 3t + 10)dt =$$
$$= \left(\frac{5}{3}t^3 - \frac{3}{2}t^2 + 10t\right)\Big|_2^5 = \frac{5}{3}(5)^3 - \frac{3}{2}(5)^2 + 10 \cdot 5 - \frac{5}{3}(2)^3 + \frac{3}{2}(2)^2$$
$$- 10 \cdot 2 = 193.5\ C.$$

Answer: b) $193.5\ C$

12) A nichrome wire is $1.0\ m$ long and $1.0\ mm^2$ in cross-sectional area. It carries a current of $4.0\ A$ when a potential difference of $2.0\ V$ is applied between its ends. Calculate conductivity of the wire:

a) $2M\Omega^{-1} \cdot m^{-1}$

b) $4k\Omega^{-1} \cdot m^{-1}$

c) $2m\Omega^{-1} \cdot m^{-1}$

d) $4\Omega^{-1} \cdot m^{-1}$

Solution:

Conductivity is defined as the inverse of resistivity ρ:

$$\sigma = \frac{1}{\rho}$$

As we know, resistivity defined as:

$$\rho = R\frac{A}{l},$$

here, R is the resistance of the wire, A is the cross-sectional area of the wire and l is the length of the wire.

In order to find the resistance of the wire we use the Ohm's law and obtain:

$$R = \frac{V}{I}$$

Then, we can rewrite our formula for the resistivity:

$$\rho = \frac{V}{I} \cdot \frac{A}{l}$$

Substituting the resistivity into the formula for the conductivity we finally get:

$$\sigma = \frac{1}{\rho} = \frac{I \cdot l}{V \cdot A} = \frac{4.0\ A \cdot 1.0\ m}{2.0\ V \cdot 1.0 \cdot 10^{-6} m^2} = 2.0 \cdot 10^6 \Omega^{-1} \cdot m^{-1} = 2.0M\Omega^{-1} \cdot m^{-1}$$

Answer:

a) $2M\Omega^{-1} \cdot m^{-1}$