Answer on Question #56229, Physics / Electromagnetism

A long solenoid of radius 2 cm has 100 turns/cm and carries a current of 5A. A coil of radius 1 cm having 100 turns and a total resistance of 20 Ω is placed inside the solenoid coaxially. The coil is connected to a galvanometer. If the current in the solenoid is reversed in direction, find the charge flown through the galvanometer and how?

Solution.

$I = 5$ A –is current through solenoid; $r_s = 2$ cm $= 0.02$ m – radius of solenoid;

$r_c = 1$ cm $= 0.01$ m – radius of the coil; $N = 100$ – number of coil turns;

$R = 20$ Ω – is the total resistance of coil; $n = 100 \frac{\text{turns}}{\text{cm}} = 10^4 \frac{\text{turns}}{\text{m}}$;

$\alpha = 0$ – the angle between axes of coil and solenoid.

$$|q| = \left| \int_{t1}^{t2} I dt \right| = \left| \int_{t1}^{t2} \frac{\text{E}_{ind}}{R} dt \right| = \left| \frac{1}{R} \int_{t1}^{t2} \text{E}_{ind} dt \right|$$

$E_{ind} = -\frac{d\Phi}{dt}$ – is electromotive force of the induction; $t1, t2$ – moments of time before and after change current direction;

$$|q| = \left| \frac{1}{R} \int_{t1}^{t2} \frac{d\Phi}{dt} dt \right| = \frac{1}{R} |\Phi(t2) - \Phi(t1)|$$

$\Phi = NBS \cos \alpha$ – the total magnetic flux trough coil; $S = \pi r_c^2$ – area of the coil;

$$|q| = \frac{NS \cos \alpha}{R} |B(t2) - B(t1)|$$

Let B_0 – magnetic field before current reversed, then $B(t2) = -B_0, B(t1) = B_0$

$$|q| = \frac{NS \cos \alpha}{R} |-B_0 - B_0| = \frac{2B_0 NS \cos \alpha}{R}$$

$B_0 = \mu_0 In$ – magnetic field in solenoid;

$\mu_0 = 4\pi * 10^7$ H/m – magnetic constant;

$$|q| = 2\mu_0 nNS \frac{I}{R} \cos \alpha = 2\pi \mu_0 nNr_c^2 \frac{I}{R} \cos \alpha$$

$$|q| = 2 * 3.14 * 4 * 3.14 * 10^4 * 10^2 * (10^{-2})^2 * \frac{5}{20} * \cos 0 \approx 1.97 * 10^{-4}(\text{C})$$

According to Lenz's law, direction of current in coil is the same as direction of current in solenoid before direction reversed.

Answer: $1.97 * 10^{-4}$ C, direction of current in coil is the same as direction of current in solenoid before direction reversed.