Answer on Question #74119, Physics / Electromagnetism

Question. A coil is nested inside a larger coil. When the current in the outer coil is changed, there is an induced current in the inner coil. If we double the loop density n of the outer coil, by what factor will the induced current in the inner coil change? What about if we instead double n_0 in the inner coil (while keeping the length constant)?.

Solution.

According to Faraday's law of induction

$$\mathcal{E}_i = -N\frac{d\Phi}{dt} = -N\frac{d}{dt}(BS) = -(n_0 l)\frac{d}{dt}(\mu_0 nIS) = -\mu_0 nS(n_0 l)\frac{dI}{dt}$$

If we double the loop density n of the outer coil then

$$\mathcal{E}_{i1} = -\mu_0 2nS(n_0 l)\frac{dI}{dt}$$

$$\frac{\mathcal{E}_{i1}}{\mathcal{E}_i} = 2 \;\rightarrow\; \mathcal{E}_{i1} = 2\mathcal{E}_i.$$

So, the induced current in the inner coil is increased by 2 times. if we double n_0 in the inner coil then

$$\mathcal{E}_{i1} = -\mu_0 nS(2n_0 l)\frac{dI}{dt}$$

$$\frac{\mathcal{E}_{i2}}{\mathcal{E}_i} = 2 \;\rightarrow\; \mathcal{E}_{i2} = 2\mathcal{E}_i.$$

So, the induced current in the inner coil is increased by 2 times too.