Answer on question #61361, Physics, Electromagnetism

7) A coil of inductance 2.0H and resistance 5Ê is connected to a 30V battery. Calculate the rate of current growth in the coil when the circuit has just been made and when the current reaches one-half of its steady-state value.

a) 15A/s and 7.5A/s
b) 3.5A/s and 10A/s
c) 12A/s and 4.4A/s
d) 6.2A/s and 18A/s

Solution:

When t= 0 the rate of current growth is

$$\frac{di}{dt} = \frac{\mathcal{E}}{L}$$

Where, the EMF due to the battery is ε; L is inductance

Then,

$$\frac{di}{dt} = \frac{30\ V}{2.0\ H} = 15\ A/s$$

When

$$I_s = \frac{1}{2} I$$

$$\frac{di_s}{dt} = \frac{1}{2}\frac{di}{dt} = \frac{1}{2} \cdot 15 \frac{A}{s} = 7{,}5 \frac{A}{s}$$

Answer: 15 A/s, and 7.5A/s

8) A 1000-turns coil of cross-sectional area 30cm2 rotates at a frequency of 120 Hz in a magnetic field 0.1 T. Calculate the peak value of the induced emf

a) 346.4V
b) 112.3V
c) 97.6V
d) 226.2V

Solution:

The induced EMF, according to Faraday's law is

$$\mathcal{E} = -\frac{d\phi}{dt}$$

The magnetic flux might be expressed as

$$\phi = NBA\cos\theta$$

Here, $\mathcal{E}$ is the EMF generated between the ends of the coil, N is the number of turns of the coil, B is the magnetic field, A is the cross-sectional area of the coil, is the angle between the magnetic field and the normal to the plane of the coil.

$$\mathcal{E} = -NBA\frac{d(\cos\omega t)}{dt}\ (since\ \theta = \omega t)$$

$$\mathcal{E} = -NBA\omega sin\omega t$$

The peak value of the EMF induced in the coil when θ=ωt=90°

Then,

$$\mathcal{E}_{\mathrm{p}} = NBA\omega$$

Where,

$$\omega = 2\pi f$$

Finally,

$$\mathcal{E}_p = 2\pi NBAf$$

$$\mathcal{E}_p = 2\pi \times 1000\ turns \times 0.1\ T \times 30 \cdot 10^{-2} \times 120 s^{-1} = 226.2\ V$$

Answer: 226.2V