Tutorial for chapter 6

- M & magnetization current I_c

$$M = \frac{\sum m}{V} \qquad \vec{\boldsymbol{i}}_S = \overrightarrow{\boldsymbol{M}} \times \vec{\boldsymbol{n}}$$

$$\oint \overrightarrow{\boldsymbol{M}} \cdot d\vec{\boldsymbol{l}} = I_S$$

- Magnetic intensity

$$\overrightarrow{\boldsymbol{H}} = \frac{\overrightarrow{\boldsymbol{B}}}{\mu_0} - \overrightarrow{\boldsymbol{M}}$$

- Ampere's circuital Law in magnetic material

$$\oint \overrightarrow{\boldsymbol{H}} \cdot d\vec{\boldsymbol{l}} = \sum I_C$$

- Linear and isotropic—homogenous materials

$$\overrightarrow{\boldsymbol{M}} = \chi_m \overrightarrow{\boldsymbol{H}}$$

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- Linear and isotropic—homogenous materials

$$\vec{\boldsymbol{B}} = \mu_r \mu_0 \vec{\boldsymbol{H}}$$

- Permeability

$$\mu = \frac{B}{H}$$

- Initial permeability

$$\mu_i = \frac{dB}{dH}$$

Tutorial for chapter 6

6.1. A toroid having 500 turns of wire and a mean circumferential length of 50 cm carries a current of 0.3 A. The relative permeability of the core is 600.

(a) What is the magnetic field in the core?

(b) What is the magnetic intensity?

(c) What part of the magnetic field is due to surface currents?

Solution: (a) According Ampere's law for Magnetic intensity

$$\oint \overrightarrow{\boldsymbol{H}} \cdot d\vec{\boldsymbol{l}} = \sum I_C$$

$$Hl = NI$$

$$H = \frac{NI}{l} = \frac{500 \times 0.3}{50 \times 10^{-2}} = 300 A/m$$

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(b) From the relation B to H

$$\vec{\boldsymbol{B}} = \mu_r \mu_0 \vec{\boldsymbol{H}}$$

$$B = \mu_r \mu_0 H = 600 \times 4\pi \times 10^{-7} \times 300 = 0.226T$$

(c) If there is no magnetic material in the toroid

$$\oint \vec{\boldsymbol{B}} \cdot d\vec{\boldsymbol{l}} = \mu_0 \sum I$$

$$B_0 l = \mu_0 NI$$

$$B_0 = \frac{\mu_0 NI}{l} = \frac{4\pi \times 10^{-7} \times 500 \times 0.3}{50 \times 10^{-2}} = 3.77 \times 10^{-4} T$$

$B' = B - B_0 = 0.226 - 3.77 \times 10^{-4} = 0.2257T$

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6.2.The current in the windings on a toroid is 2.0 A. There are 400 turns and the mean circumferential length is 40 cm. With the aid of a search coil and charge-measuring instrument, the magnetic field B is found to be 1.0 T. Calculate

(a) the magnetic intensity H,
(b) the magnetization,
(c) the magnetic susceptibility,
(d) the equivalent surface current, and
(e) the relative permeability.

Solution: (a) Find the B_0 without magnetic material first.

$$\oint \vec{\boldsymbol{B}} \cdot d\vec{\boldsymbol{l}} = \mu_0 \sum I$$

$$B_0 l = \mu_0 N I$$

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$$B_0 = \frac{\mu_0 NI}{l} = \frac{4\pi\times10^{-7}\times400\times2.0}{40\times10^{-2}} = 2.512\times10^{-3}T$$

$B' = B - B_0 = 1.0 - 2.512\times10^{-3} = 0.9975T$

$B' = \mu_0 i' = \mu_0 M$

$$M = \frac{B'}{\mu_0} = \frac{0.9975}{4\pi\times10^{-7}} = 7.94\times10^{5}A/m$$

$$H = \frac{B}{\mu_0} - M = \frac{B_0 + B'}{\mu_0} - M = \frac{B_0 + B' - \mu_0 M}{\mu_0}$$

$$H = \frac{B_0}{\mu_0} = \frac{2.512\times10^{-3}}{4\pi\times10^{-7}} = 2000A/m$$

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$$\chi_m = \frac{M}{H} = \frac{7.94\times10^5}{2000} = 397$$

$$i' = M = 7.94\times10^5 \, A/m$$

$\mu_r = \chi_m + 1 = 398$

Tutorial for chapter 6

6.5.Table 6.3 lists corresponding values of *H* and *B* for a specimen of commercial hot-rolled silicon steel, a material widely used in transformer cores.

(a) Construct graphs of *B* and μ as functions of *H*, in the range from *H*= 0 to *H*= l000A/m.

(b) What is the maximum permeability?

(c) What is the initial permeability (*H* = 0)?

(d) What is the permeability when H =800,000A/m?

Solution: (a) See the Graphs on next page

(b) μ_m=0.54/50=0.0108T·m·A^{-1}

(c) the initial permeability μ_i=0.05/10=0.005T·m·A-1

(d)μ=2.92/800000=0.00000365T·m·A^{-1}

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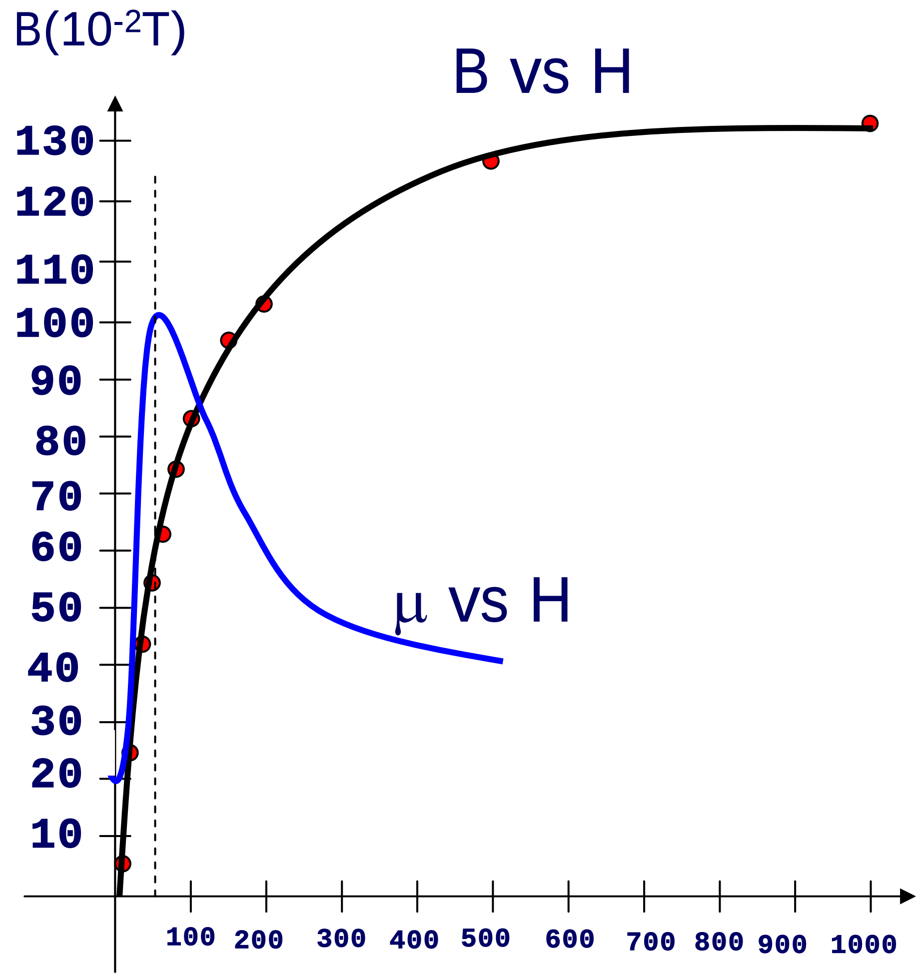
Magnetic intensity H, (A/m)	Flux density B, (T)
0	0
10	0.050
20	0.15
40	0.43
50	0.54
60	0.62
80	0.74
100	0.83
150	0.98
200	1.07
500	1.27
1000	1.34
800000	2.92



Tutorial for chapter 6

6.8.A bar magnet has a coercivity of 4×10^3 A/m. It is desired to demagnetize it by inserting it inside a solenoid 12 cm long and having 60 turns. What current should be carried by the solenoid?

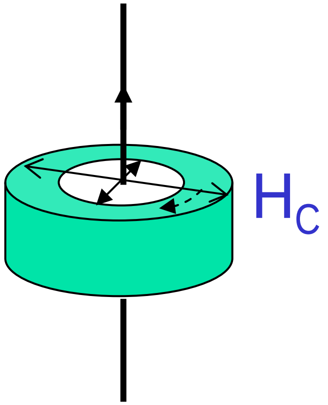
Solution:

$$H = nI$$

$$I = \frac{H_c}{n} = \frac{4\times10^{3}\times12\times10^{-2}}{60} = 8A$$

Tutorial for chapter 6

Rectangular Ferromagnetism, memory element in computer. d_1=0.5mm, d_2=0.8mm, H_c=2 Oersted. If we want to make the direction of magnetization opposite, what is the current in the wire?



Tutorial for chapter 6

6.10.A Rowland ring has a cross section of 2 cm^2, a mean length of 30 cm, and is wound with 400 turns. Find the current in the winding that is required to set up a flux density of 0.1 T in the ring,

(a) if the ring is of annealed iron (Fig. 6.3);

(b) if the ring is of silicon steel (Table 6.3).

(c) Repeat the computations above if a flux density of 1.2 T is desired.