

ENGG 2120 Fall 2011 Chapter 20 Assignment with answers

1. A coil of wire 0.10 m long and having 100 turns carries a current of 10 A.

(a) What is the magnitude of the magnetic field strength H ?

(b) Compute the flux density B_0 if the coil is in a vacuum.

(Permeability of vacuum is given by $4\pi \times 10^{-7} \text{ H/m}$)

Ans:

(a) Given length of wire = 0.10 m

Current = 10 A

Number of turns = 100

Magnetic field strength generated by coil is given by

$$H = \frac{NI}{l}$$

Where,

H- Magnetic field strength

I- Current (10A)

l- Length of the coil (0.1m)

N- Number of turns (100) and, incorporating the above values in the given equation leads to the magnitude of the magnetic field strength H

$$= \frac{(100 \text{ turns})(10 \text{ A})}{0.10 \text{ m}} = 10,000 \text{ A - turns/m}$$

(b) Magnetic flux density in vacuum is given by

$$B_0 = \mu_0 H$$

$$\begin{aligned} &= (4\pi \times 10^{-7} \text{ H/m})(10,000 \text{ A - turns/m}) = (12.56 \times 10^{-7} \text{ H/m})(10,000 \text{ A - turns/m}) \\ &= 1.256 \times 10^{-2} \text{ tesla} \end{aligned}$$

2. A coil of wire 'l' long and having N turns carries a current of 'I' produces magnetic field strength 'H'. What is the magnitude of the magnetic field strength H, if current is doubled and number of turns are increased by 3 times?

Ans:

Magnetic field strength of a coil of wire of length 'l', N number of turns and 'I' is current passing through it is given by

$$H = \frac{NI}{l}$$

Initial length = l

Initial current = I

Initial no. of turns = N

Initial magnetic field strength $H_i = \frac{NI}{l}$

Final length = l

Final current = 2I

Final no. of turns = 3N

Final magnetic field strength $H_f = \frac{(3N)2I}{l} = \frac{6NI}{l} = 6H_i$

Therefore magnetic field strength is increased by 6 times.

3. Demonstrate that the relative permeability (μ_r) and the magnetic susceptibility (χ_m) are related according to Equation $\chi_m = \mu_r - 1$

Ans:

We begin with Equation $B = \mu_0 H + \mu_0 M$ and substitute for M using equation $M = \chi_m H$.

Thus,

$$B = \mu_0 H + \mu_0 M = \mu_0 H + \mu_0 \chi_m H$$

But B is also defined as

$$B = \mu H$$

When the above two expressions are set equal to one another as

$$\mu H = \mu_0 H + \mu_0 \chi_m H$$

This leads to

$$\mu = \mu_0(1 + \chi_m)$$

If we divide both sides of this expression by μ_0 , and from the definition of μ_r , $\mu_r = \frac{\mu}{\mu_0}$ then

$$\frac{\mu}{\mu_0} = \mu_r = 1 + \chi_m$$

or, upon rearrangement

$$\chi_m = \mu_r - 1$$

This is the desired result.

4. (a) Explain the two sources of magnetic moments for electrons.
- (b) Do all electrons have a net magnetic moment? Why or why not?
- (c) Do all atoms have a net magnetic moment? Why or why not?

Ans:

- (a) The two sources of magnetic moments for electrons are the electron's orbital motion around the nucleus, and also, its spin.
- (b) Each electron will have a net magnetic moment from spin, and possibly, orbital contributions, which do not cancel for an isolated electron.
- (c) All atoms do not have a net magnetic moment. If an atom has completely filled electron shells or sub shells, there will be a cancellation of both orbital and spin magnetic moments.

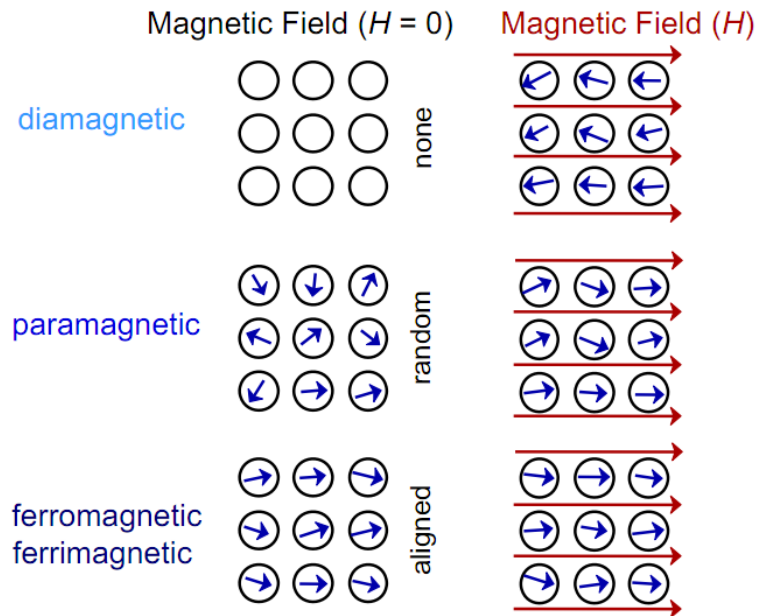
5. Name the 3 types of magnetisms with examples.

Ans:

1. Ferromagnetic e.g. Fe_3O_4 , NiFe_2O_4
2. Paramagnetic e.g. Al, Cr, Mo, Na, Ti, Zr
3. Diamagnetic e.g. Cu, Au, Si, Ag, Zn

6. Give schematic illustration of the atomic dipoles for a Diamagnetic, Paramagnetic and Ferromagnetic material, in the absence and presence of an external magnetic field.

Ans:



7. Match the following

Quantity

1. Magnetic field Strength
2. Susceptibility
3. Magnetic induction
4. Permeability

Units

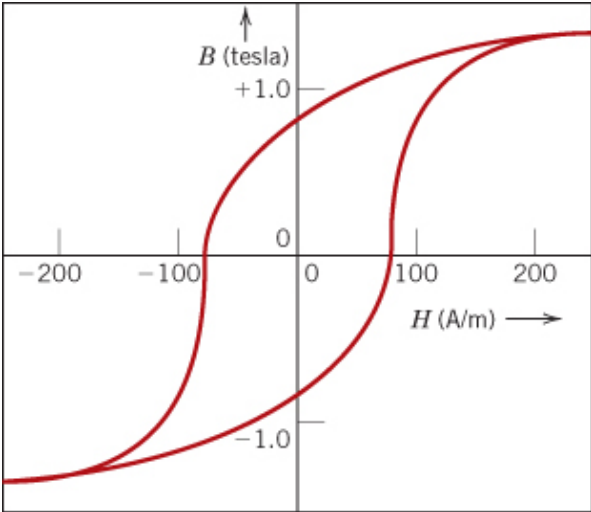
- A. Tesla
- B. Henry/m
- C. Unit less
- D. Amp-turn/m

Ans:

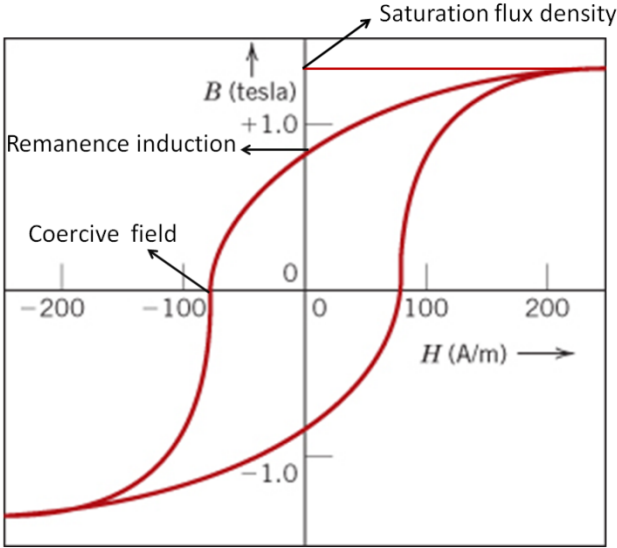
1-D, 2-C, 3-A, 4-B

8. The figure shows B versus H curve for a steel alloy. Identify the following points.

- (a) Saturation flux density
- (c) Remanence induction
- (d) Coercivity value



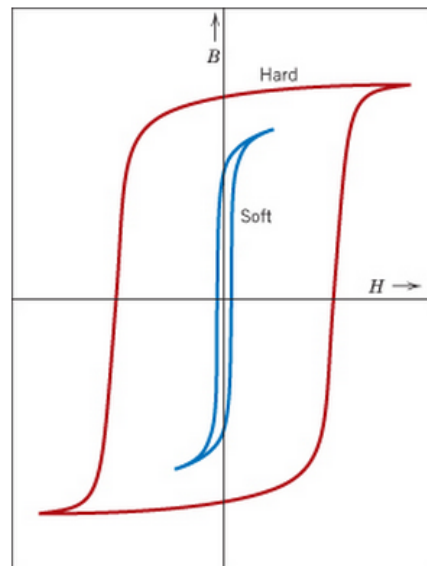
Ans:



9. Cite the differences between hard and soft magnetic materials in terms of both hysteresis behavior (with schematics) and typical applications.

Ans:

Relative to hysteresis behavior, a hard magnetic material has a high remanence, a high coercivity, a high saturation flux density, high hysteresis energy losses and a low initial permeability; a soft magnetic material, on the other hand, has a low coercivity, low hysteresis energy losses and a high initial permeability.



With regard to applications, hard magnetic materials are utilized for permanent magnets; soft magnetic materials are used in devices that are subjected to alternating magnetic fields such as transformer cores, generators, motors, and magnetic amplifier devices.