

Magnetic Materials

1. An ideal solenoid has 500 turns per metre of wire wound on an iron core with a constant $\mu_r = 800$. If the current in the windings is 0.5 A calculate H, B and M in the iron. [Ans: $H=250$ A/m, $B=0.25$ T, $M=2.0 \times 10^5$ A/m]
2. A toroidal current-carrying winding is wound about an iron toroid with a small air gap. The length of the iron path is 50 cm and the air gap is 1 mm. If the magnetic induction in the iron is 1.5T find (a) B_{gap} , (b) H_{iron} , (c) H_{gap} . Take $\mu_r = 5000$ for the iron and ignore flux leakage. [Ans: (a) 1.6 T, (b) 240 A/m, (c) 1.2×10^6 A/m]

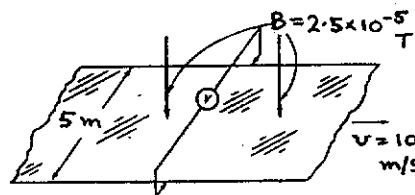
Induction

3. A square loop of wire with sides of length a lies in a plane with a long straight wire carrying a current I so that the nearest side of the square is parallel to the current and a distance b from it. (a) Find the magnetic flux through the loop. (b) If the loop is pulled away from the wire with velocity v , what emf is generated and what is its direction?

[Ans: $\Phi_B = (\mu_0 I a / 2\pi) \ln(1 + a/b)$, $emf = \mu_0 I v a^2 / 2\pi (b + vt)(a + b + vt)$]

4. A small circular search coil is used to search for stray magnetic fields around a transformer. The coil diameter is 2 cm, its length is essentially zero and its output is connected to an infinite impedance voltmeter. For a stray field of amplitude 1 mT at 50 Hz, how many turns would be required for the coil to produce a 1 mV rms input to the voltmeter? [Ans: 14]

5. An aluminium sheet has a velocity normal to a uniform magnetic field as shown. Find the voltage induced between the edges of the sheet.



[Ans: 1.25 mV].

6. An open circuited rectangular conducting loop, 6 cm x 12 cm, is spinning at 8000 rpm. If the field normal to the loop axis is $H = 40$ A/m, what is the rms voltage induced in the loop? [Ans: 2.1×10^{-4} V]
7. A 10 cm diameter single turn circular conducting loop is spinning about an axis perpendicular to a magnetic field at a rate of 10,000 rpm. The current induced in the loop is 2 A rms. If the resistance of the loop is 0.1 Ω , find (a) the average power required to spin the loop and (b) the average torque on the loop.

[Ans: $P_{av} = 0.4$ W, $T_{av} = 3.8 \times 10^{-4}$ Nm]

Maxwell's Equations

[In the following t is in sec, x,y,z are in metres]

8. The electric field of a light wave in vacuum is $\mathbf{E} = 10 \cos(\omega(t-z/c))\hat{\mathbf{x}}$ V/m. Obtain an expression for the magnetic field \mathbf{H} . [Ans: $\mathbf{H} = 2.65 \times 10^{-2} \cos(\omega(t-z/c))\hat{\mathbf{y}}$ A/m]

9. The electric field of a wave in a medium where $\mu = \mu_0$ is $\mathbf{E} = 250 \cos(10^9 t - 5x)\hat{\mathbf{z}}$ V/m. Find (a) the direction of wave travel, (b) the velocity of the wave and (c) an expression for the \mathbf{H} field.

[Ans: (a) +x dir'n, (b) 2×10^8 m/s, (c) $\mathbf{H} = -\cos(10^9 t - 5x)\hat{\mathbf{y}}$ A/m]

10. The electric field of a wave is $\mathbf{E} = 100 \cos(2\pi \times 10^8 t - 3y)\hat{\mathbf{x}}$ V/m. Find (a) the relative permittivity of the medium, and (b) the wavelength. [Ans: (a) 2.05, (b) 2.09 m]