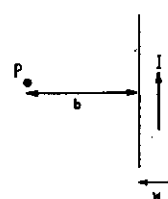


Magnetic Fields

1. A long thin flat strip of metal is of width W and has a current I flowing along it. Find the magnetic induction B at a point P in the plane of the strip at a distance b from the nearest edge.



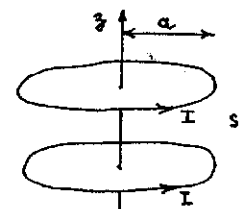
[Ans: $(\mu_0 I / 2\pi W) \ln(1 + W/b)$]

2. A coaxial line carries the same current I up a solid inside conductor of radius a as down an outer conductor of inner radius b and outer radius c . The current density J is uniform within each conductor. Find the magnetic induction as a function of distance from the axis for all r .

[Ans: $r < a$: $\mu_0 I r / 2\pi a^2$; $a < r < b$: $\mu_0 I / 2\pi r$;
 $b < r < c$: $(\mu_0 I / 2\pi r)[(c^2 - r^2)/(c^2 - b^2)]$; $c < r$: 0]

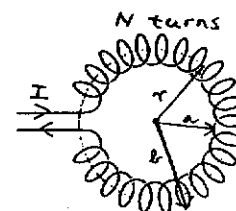
3. The arrangement shown in the diagram is often used to provide a uniform field to cancel the Earth's magnetic field over a limited volume (Helmholtz coils). Two coils each of radius a carrying the same current I are separated by a distance s . The most uniform field is obtained by placing the coils so that the points where the second derivative of the fields of the individual coils are zero coincide.

- a) Show that for a single loop $(d^2 B / dz^2) = 0$ at a distance along the axis equal to half the radius of the loop.
- b) Thus for maximum uniformity the loops should be placed so that $s = a$. Show that in that case the resultant field on the axis halfway between the coils is $B = 8\mu_0 I / (5^{3/2} a)$.
- c) Find the current required to cancel the Earth's field of 5×10^{-5} T if each coil has 10 turns and $a = 0.5$ m. [Ans: 2.8 A]



4. What is the field within the torus shown if $a = 10$ cm, $b = 12$ cm, $I = 5$ mA and $N = 500$?

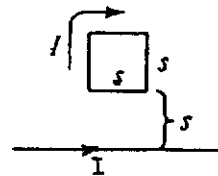
[Ans: 4.5×10^{-6} T]



5. Assume that a uniformly wound solenoid, $L = 10$ cm, $r = 1$ cm, is used to compensate for the Earth's field. If $N = 10000$ turns, find the current required to produce $B = 5 \times 10^{-5}$ T in the centre of the solenoid. [Ans: 0.4 mA]

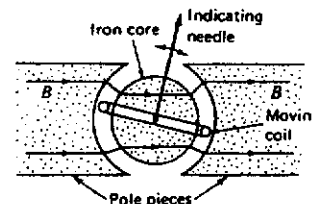
Magnetic Forces

6. Find the force of translation on a square conductor current loop when immersed in the field of a current-carrying filamentary conductor of infinite length as shown in the figure.



[Ans: $F = \mu_0 I^2 / 4\pi$, outwards]

7. The radial magnetic field experienced by the moving coil of a current meter is 0.8 T. The coil is restrained by a spring (not shown) with a torque per unit angle of 2×10^{-6} Nm per degree. Find the current which would cause the coil to deflect through an angle of 45° if the coil has 50 turns and measures 0.016 m across by 0.025 m perpendicular to the page.



[Ans: 5.6 mA]

8. A magnetic dipole has an initial value of $\mathbf{m} = 5\hat{\mathbf{r}} \mu\text{Am}^2$ when placed 2 m from an infinite length conductor along the z axis. It is free to rotate but not translate. If the current in the conductor is 10 A in the +z direction, find the initial and final torques on the magnetic dipole.
[Ans: $T_i = 5 \times 10^{-12}\hat{\mathbf{z}}$, $T_f = 0$]
9. Two infinite and parallel conductor sheets carry surface currents $\mathbf{K} = 5 \text{ A/m}$ in opposite directions. If the separation of the sheets is 1 mm find the force of repulsion per square metre.
[Ans: $1.57 \times 10^{-5} \text{ N}$]

Magnetic Materials

10. A long bar of magnetic material is parallel to the y axis with its cross-section defined by $0 \leq x \leq 0.1 \text{ m}$, and $0 \leq z \leq 0.2 \text{ m}$. If the magnetization in the bar is $\mathbf{M} = 3x\hat{\mathbf{y}} \text{ A/m}$, find (a) \mathbf{J}_m within the material and (b) \mathbf{J}_{sm} on the four surfaces.
[Ans: (a) $\mathbf{J}_m = 3\hat{\mathbf{z}} \text{ Am}^{-2}$, (b) $\mathbf{J}_{sm} = -0.3\hat{\mathbf{z}} \text{ A/m}$ at $x = 0.1$, 0 at $x = 0$, $-3x\hat{\mathbf{x}}$ at $y = 0$ and $3x\hat{\mathbf{x}}$ at $y = 0.2$.]