Physics Tutorial 17

Magnetic Fields and Electromagnetism

Assume $\mu_O = 4\pi \times 10^{-7}$ H m^{-1} ; electronic charge $e = 1.6 \times 10^{-19}$ C ; $g = 9.8$ m s^{-2}.

1. Two long straight parallel wires are separated by a distance 2*a*. If the wires carry equal currents in opposite directions, what is the magnetic field in the plane of the wires and at a point

(a) midway between them, and

(b) a distance *a* from one and 3*a* from the other?

(c) For a case in which the wires carry equal currents in the same directions, answer **(a)** and **(b)**.

(The flux density at a perpendicular distance *r* from a very long straight wire carrying a current I is given by $B = \frac{\mu_o I}{2\pi r}$.) Ans: (a) $\frac{\mu_o I}{\pi a}$ (b) $\frac{\mu_o I}{3\pi a}$ (c) 0, $\frac{2\mu_o I}{3\pi a}$

2. A small magnet, suspended with its axis horizontal so as to rotate freely about a vertical axis, is situated at the centre of a long horizontal solenoid, the axis of which lies at right angles to the magnetic meridian. If the solenoid has 2000 turns per metre, determine the value of the current passing through it which would cause the magnet to rotate through 50 degrees.
(Horizontal component of earth's magnetic field is 1.8×10^{-5} T; magnetic flux density at the centre of a solenoid = $\mu_o nI$ where *n* is the number of turns per unit length of the solenoid and I is the current through it.) Ans: 8.5 mA

3. An α–particle, of mass 6.7×10^{-27} kg and charge +2*e* , travels in a circular path of radius 0.45 m in a magnetic field of flux density *B* = 1.2 T. Calculate **(a)** its speed, **(b)** its period of revolution, **(c)** its kinetic energy, and **(d)** the potential difference through which it would have to be accelerated to achieve this energy.
Ans: (a) 2.6×10^{7} m s^{-1} (b) 1.1×10^{-7} s (c) 2.2×10^{-12} J (d) 7.0×10^{6} V

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5. Fig. 2 shows a long wire XY carrying a current of 30A. The rectangular loop ABCD carries a current of 20A.

(a) Calculate the magnetic field due to XY along **(i)** AD and **(ii)** BC. (The flux density at a perpendicular distance *r* from a very long straight wire carrying a current I is given by $B=\mu_o I/2\pi r$.)

(b) Hence calculate the resultant force acting on the loop.

Take *a* = 1.0 cm, *b* = 8.0 cm and l = 30 cm.
Ans: (a)(i) 6.0×10^{-4} T (ii) 6.7×10^{-5} T (b) 3.2×10^{-3} N towards the wire.

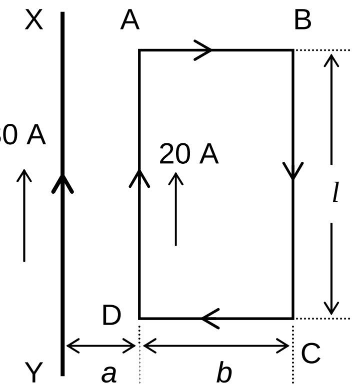

Fig. 2

6. The rectangular loop of wire in Fig. 3 has a mass of 0.10 g per centimetre of length, and is pivoted about side AB as a frictionless axis. The current I in the wire is 10 A in the direction shown.

(a) Calculate the magnitude and state the direction of the magnetic field, parallel to the Y–axis, that will cause the loop to swing up until its plane makes an angle of 30^0 with the YZ–plane.

(b) Discuss the case in which the field is parallel to the X–axis. Ans: (a) 1.3×10^{-2} T

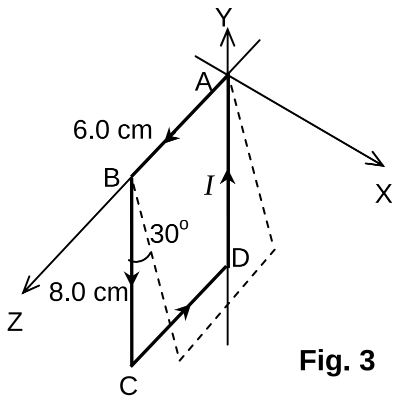

Fig. 3

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