PHYS1022 Electricity and Magnetism

Problem Sheet 9: workshop

1 Use Ampere's law to find

(a) the magnetic field strength at a distance of 0.10 mm from the axis of a 1.0 mm diameter wire carrying 5.0 A distributed uniformly over its cross section,

(b) the magnetic field strength at a distance of 2.0 mm from the axis of the wire, and

(c) the magnetic field strength at the surface of the wire.

Are your answers to (a) and (b) consistent with (c)?

2 The flux through a loop is given by $\Phi_M = (t^2 - 4t) \times 10^{-1}$ Wb, where t is in seconds.

(a) Find the induced emf $\mathcal{E}$ as a function of time.

(b) Find both Φ_M and $\mathcal{E}$ at $t = 0$, $t = 2$, $t = 4$ s, and $t = 6$ s. Set out your answers in a table.

(c) Sketch graphs of Φ_M and $\mathcal{E}$ versus t.

(d) At what time is the flux minimum? What is the emf at this time?

(e) At what times is the flux zero? What is the emf at these times?

3. Earth's magnetic field can be approximated by a dipole field (as if there is a current loop at the centre of the Earth). Earth's dipole moment is 8.0×10^{22} A.m^2. What is the magnetic field strength on Earth's surface at either pole? You may use equation 26.9 from Wolfson, as derived in lectures, explaining all terms used.
Radius of Earth, $R_E = 6.37 \times 10^6$ m.

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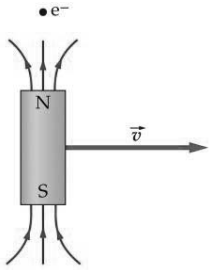
Problem Sheet 8: tutorials



1. A magnet flying at high speed flies by an electron which is at rest relative to an observer in a laboratory. Explain why you are sure that a force must be acting on it. What direction will the force point when the north pole of the magnet passes directly underneath the electron? Explain.

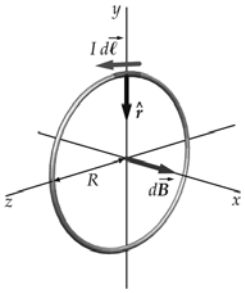
2. Compare the directions of the electric force and the magnetic force between two positive charges, which move side by side with equal velocities along parallel paths. Consider this question from different frames of reference, ie as an observer who is stationary in the coordinate frame chosen, and in a frame that moves with the charges. What happens to the magnetic force? (The explanation of this apparent paradox provided one of the paths that led to the theory of special relativity.)

3. The magnetic field induced by a moving charge is given by

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{1}{r^2}q\vec{v} \times \hat{r}$$

   Compare this to the Biot-Savart law.

   An electron orbits a proton at a radius of 5.29×10^{-11} m. What is the magnitude of the magnetic field at the proton due to the orbital motion of the electron?



4. A single-turn circular loop of radius 10.0 cm is to produce a field at its centre that will just cancel the earth's magnetic field at the equator, which is 0.7 G directed north. Make a sketch using the figure supplied that shows the orientation of the loop in the earth's field and the current. Find the current in the loop.