EEE6001 Tutorial sheet 2 - Magnetic Fields

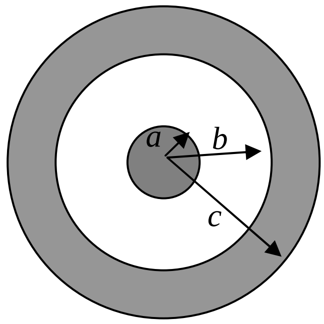
1. A long straight wire of diameter 1mm carries a current of 50A
   (a) Calculate the *B* field at the surface of the wire, and at distances of 10mm, 0.1m and 1m from the axis of the wire using the formula for an infinitely long wire.
   (b) If the wire is 1m long, calculate the *B* field 10cm from the axis of the wire at its mid point. Neglect the *B* field due to the current flowing in the rest of the circuit. What would be the percentage error in assuming that the formula for an infinitely long wire applied in this case?

2. A long wire carrying a current of 100A is placed in a uniform field of 5mT. The wire is at right angles to this field. Find where the resultant field is zero.

3. A wire of radius 2mm carries a current of 10A. Assuming the wire is infinitely long, so that the field is symmetric about the wire, use Ampere's law to calculate the *B* field at distances of 50mm, 10mm, 2mm and 1mm from the axis of the wire. For the last distance assume that the current is uniformly distributed within the wire.

4. Figure 1 shows the cross-section of a long coaxial cable which consists of two concentric conductors, shown shaded, insulated from each other. A current *I* flows out of the figure, in the inner conductor, and into the figure in the outer conductor. The currents may be assumed to be uniformly distributed within each conductor. Calculate the variation of the *B* field with position.
   (a) inside the inner conductor ($r \le a$)
   (b) between the two conductors ($a \le r \le b$)
   (c) within the outer conductor (($b \le r \le c$)
   (d) outside the outer conductor ($c \le r$)

Figure 1



5. Figure 2 shows a wire *M* carrying a 50Hz $4A_{rms}$ current from the mains which runs close to a circuit *R* which a student has constructed. The circuit is shown for simplicity as a rectangle *R* but could well consist of components mounted on a printed circuit board. What is the induced emf in the circuit *R*?

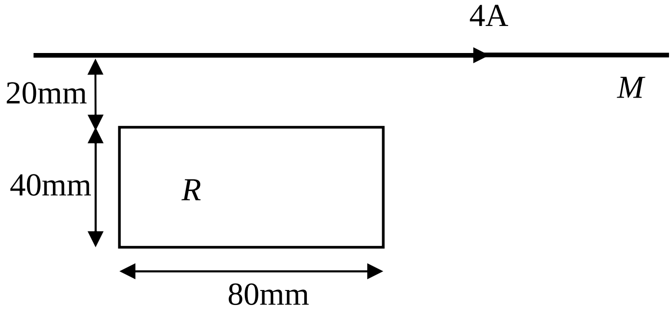


Figure 2

6. Use Ampere's law to show that the magnitude of the H field at a distance r from a long straight wire carrying current I is given by

$$H = \frac{I}{2\pi r}$$

Figure 3 shows the cross-section of four long straight wires *A, B, C* and *D* placed at the corners of a square of side *d*. The wires carry currents $\pm I_1$ or $\pm I_2$ as shown, where a positive current is into the plane of the paper. Show that the components of the force per unit length acting on wire *B* are given by:

$$F_x = \frac{\mu_0 I_1}{2\pi d}\left(\frac{I_1}{2} - I_2\right) \qquad\qquad F_y = \frac{\mu_0 I_1}{2\pi d}\left(\frac{I_1}{2} + I_2\right)$$

If d = 25mm, I_1=2A and I_2=3A calculate the magnitude and direction of the force per unit length acting on *B*.

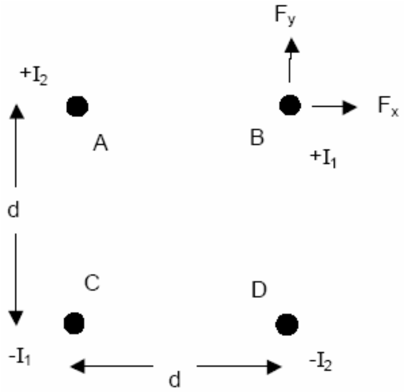


Figure 3

7. Figure 4 shows a loop circuit consisting of circular arcs and straight radial lines. The arcs have a common centre, *P* and radii *a* and *b*. Use the Biot-Savart rule to find an expression for the *B* field at the point *P*.

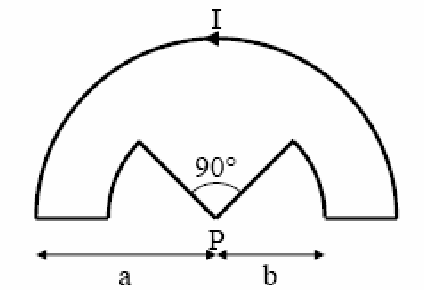


Figure 4

Figure 5 shows two circular loops of wire positioned a distance d apart. The loop on the left has *N* turns of radius *a*. The smaller loop on the right has only 1 turn of area *A*. Assuming the loops are parallel and that $A \ll d^2$, deduce an expression for the mutual inductance between the two loops. Evaluate this inductance for a=0.2m, N=150, d=0.1m and A=10^{-4}m^2

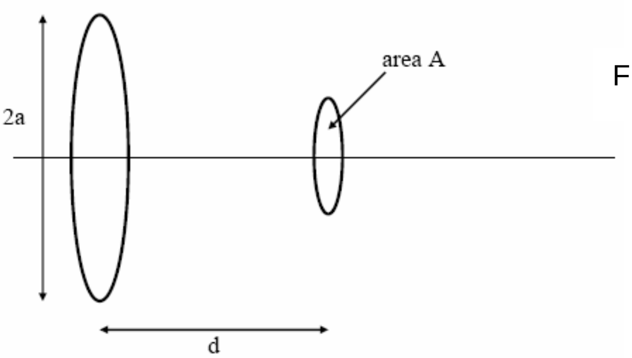


Figure 5

Other practice questions can be found on the Tutorial sheet and past exam questions for EEE220 which are posted on the web.