UNIVERSIDADE da MADEIRA

Electromagnetism

Series of problems 6

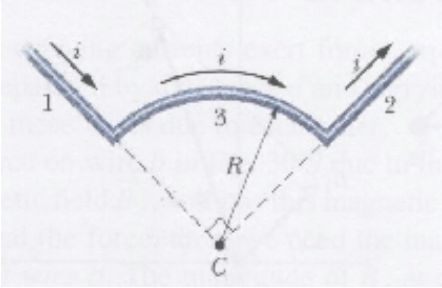
1. A wire segment of length L carries a current I. Use Biot-Savart law to find the magnetic field in the plane perpendicular to the wire and passing through the midpoint of the wire.

2. Find the magnetic field in the center of a square-sided loop, with side $L = 50cm$, that carries a current of 1.5 A.

3. Find an expression for the magnetic field in the center of a circular current loop.

4. Find an expression for the magnetic field produced in the center of a circular arc of a wire.

5. The wire in the figure carries a current I and consists of a circular arc of radius R and central angle $\pi/2$ rad, and two rectilinear sections whose extensions intersect the center C of the arc. What is the magnetic field produced by the current in C?



6. Find an expression for the magnetic field at a point on the axis of a circular current loop. Confirm that your result conforms to the calculation already made for the point in the center of the loop. Get an expression for the limiting case of large distances from the center (along the axis).

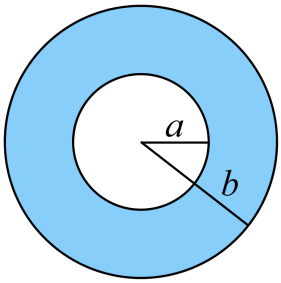
7. Consider a solenoid of length L consisting of N turns that carries a current I. Find an expression for the magnetic field at a point along the axis of the solenoid. Also find an approximate expression for the magnetic field inside a long solenoid.

8. Find the magnetic field in the center of a solenoid of length 20 cm, radius 1.4 cm and 600 turns carrying a current of 4 A.

9. A long straight wire carrying a current of 1.7 A in the positive z direction is directed along the line $x = -3\,\text{cm}, y = 0$. A similar wire carrying a current of 1.7 A in the positive z direction is directed along the line $x = +3\,\text{cm}, y = 0$. Find the magnetic field at a point P on the y axis located at $y = 6cm$.

10. A long straight wire with radius R carries a current I which is evenly distributed across the wire section. Find the magnetic field for points on and off the wire.

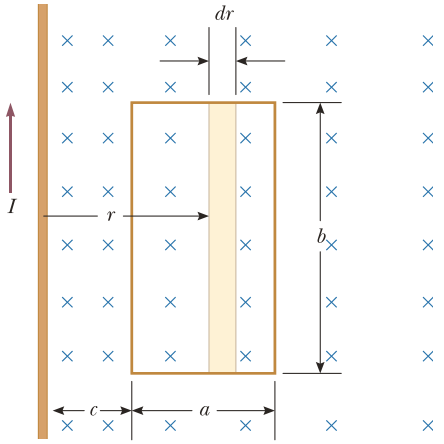
11. The figure shows the section of a long conductive cylinder with inner radius $a = 2.0$ cm and outer radius $b = 4.0$ cm. The cylinder carries a current directed out of the page, and the current density in the cross section is given by $j = cr^2$, with $c = 3,0 \times 10^6\,\text{A/m}^4$ and r in meters. What is the magnetic field magnitude B at a point that is 3.0 cm from the central axis of the cylinder?



12. A torus is commonly used to create an almost uniform magnetic field within it. The device consists of a conductive wire wrapped around a ring (or torus, or donut) made of a nonconductive material. For a torus that has N turns with small spacing between turns, calculate the magnetic field in the torus-occupied region at a distance r from the center.

13. A rectangular loop of width a and length b is located near a long wire carrying a current I (see the figure). The distance between the wire and the side closest to the loop is c. The

wire is parallel to the long side of the loop. Find the total magnetic flux through the loop due to the current in the wire.



Solutions:
1) $B = \frac{\mu_0 I}{4\pi y}(\sin\phi_1 + \sin\phi_2)$, with $\phi_1 = \phi_2$; 2) $B = 3,39 \times 10^{-6}\,\mathrm{T}$; 3) $B = \frac{\mu_0 I}{2R}$; 4) $B = \frac{\mu_0}{4\pi}\frac{I}{R}\phi$; 5) $B = \frac{\mu_0 I}{8R}$; 6) $B = \frac{\mu_0}{4\pi}\frac{2\pi I R^2}{(R^2+x^2)^{\frac{3}{2}}}$; $B_{centro} = \frac{\mu_0 I}{2R}$; $B_{x\ \mathrm{large}} = \frac{\mu_0 I R^2}{2|x|^3}$; 7) $B = \frac{\mu_0 n I}{2}\left[\frac{b}{\sqrt{b^2+R^2}} + \frac{a}{\sqrt{a^2+R^2}}\right]$ where $n = \frac{N}{L}$ and the solenoid is located at $x = -a$ and $x = b$; $B_{long} = \mu_0 n I$; 8) $B = 1,50 \times 10^{-2}\,\mathrm{T}$; 9) $\mathbf{B} = -9,07 \times 10^{-6}\,\mathrm{T}\mathbf{u}_x$; 10) For $r > R$: $B = \frac{\mu_0 I}{2\pi r}$;For $r < R$: $B = \frac{\mu_0 I}{2\pi}\frac{r}{R^2}$; 11) $B = 2,0 \times 10^{-5}\,\mathrm{T}$; 12) $B = \frac{\mu_0 N I}{2\pi r}$; 13) $\Phi_B = \frac{\mu_0 I b}{2\pi}\ln\left(1 + \frac{a}{c}\right)$.