

13. Our x axis is along the wire with the origin at the right endpoint, and the current is in the positive x direction. All segments of the wire produce magnetic fields at P_2 that are out of the page. According to the Biot-Savart law, the magnitude of the field any (infinitesimal) segment produces at P_2 is given by

$$dB = \frac{\mu_0 i}{4\pi} \frac{\sin \theta}{r^2} dx$$

where θ (the angle between the segment and a line drawn from the segment to P_2) and r (the length of that line) are functions of x . Replacing r with $\sqrt{x^2 + R^2}$ and $\sin \theta$ with $R/r = R/\sqrt{x^2 + R^2}$, we integrate from $x = -L$ to $x = 0$. The total field is

$$B = \frac{\mu_0 i R}{4\pi} \int_{-L}^0 \frac{dx}{(x^2 + R^2)^{3/2}} = \frac{\mu_0 i R}{4\pi} \frac{1}{R^2} \frac{x}{(x^2 + R^2)^{1/2}} \bigg|_{-L}^0 = \frac{\mu_0 i}{4\pi R} \frac{L}{\sqrt{L^2 + R^2}} .$$