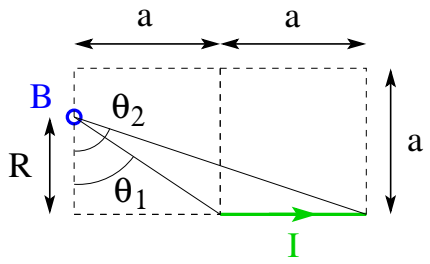
[lex52] Magnetic field of straight current segment II

In [lex51] we have shown that the magnetic field generated by a straight segment of current is conveniently expressible in the form,

$$B = \frac{\mu_0}{4\pi}\frac{I}{R}(\sin\theta_2 - \sin\theta_1), \qquad L = R(\tan\theta_2 - \tan\theta_1),$$

with the specifications R, θ_1, θ_2 as shown, and where L is the length of the segment. What happens when we reduce the distance R of the field point from the line of current toward zero such that it approaches the line to the side of the current segment as shown? Both the numerator and the denominator of the above expression approach zero, which requires a more detailed analysis. For the situation shown we must expand the angles θ_1 and θ_2 in powers of R/a and then take the limit $R \to 0$. Carry out that limit and show that the magnetic field B vanishes in that limit.

The general conclusion from this exercise is that any straight segment of current that flows away from or toward the field point does not contribute to the magnetic field at that location.



Solution: