5.14 A long, East-West–oriented power cable carrying an unknown current I is at a height of 4 m above the Earth's surface. If the magnetic flux density recorded by a magnetic-field meter placed at the surface is 15 μT when the current is flowing through the cable and 20 μT when the current is zero, what is the magnitude of I?

Solution: The power cable is producing a magnetic flux density that opposes Earth's, own magnetic field. An East–West cable would produce a field whose direction at the surface is along North–South. The flux density due to the cable is

$$B = (20 - 15)\ \mu\text{T} = 5\mu\text{T}.$$

As a magnet, the Earth's field lines are directed from the South Pole to the North Pole inside the Earth and the opposite on the surface. Thus the lines at the surface are from North to South, which means that the field created by the cable is from South to North. Hence, by the right-hand rule, the current direction is toward the East. Its magnitude is obtained from

$$5\ \mu\text{T} = 5 \times 10^{-6} = \frac{\mu_0 I}{2\pi d} = \frac{4\pi \times 10^{-7} I}{2\pi \times 4},$$

which gives $I = 100$ A.