(3) Suppose that a reversal of the Earth’s magnetic field, starting now, is completed in \(10^4\) years. The equatorial line integral of \(E\) during that time will be about how many millivolts?

The flux through the circle of Earth radius \(R\) that represents the magnetic equator is equal to the flux returning through the equatorial plane outside the Earth. We may assume the external field is that of a central dipole, with intensity \(B_0\) at \(r = R\). For \(r > R\) the field strength at the equatorial plane is \(B_0(R/r)^3\). The flux crossing the equatorial plane is \(\int_{R}^{\infty} 2\pi r B(r) \, dr = 2\pi R^2 B_0\). With \(B_0 = 0.3\) G and \(R = 6 \times 10^8\) cm, the flux is \(6.6 \times 10^{17}\) G cm\(^2\). If this reverses in \(10^4\) years, or \(3 \times 10^{11}\) s, changing at a constant rate, the voltage induced in the equatorial ring will be approximately 40 mV.