(3.6) Possible and impossible fields

An electric field points everywhere in the z-direction.

(a) What can you conclude about the values of the partial derivatives of $\boldsymbol{E}$ with respect to x, y, z (i) if the space charge density ρ is zero and (ii) if ρ is not zero?

(b) Sketch lines of $\boldsymbol{E}$ for one possible and for one impossible field, on the assumption that $\nabla \times \boldsymbol{E} = 0$.

(3.6) The Earth's electric charge

The electric field strength in the atmosphere near the surface of the Earth is about 100 volts/meter and points downward. The potential increases with increasing height, up to about 300,000 volts. This field is maintained by thunderstorms, which deposit negative charge on the Earth at the average rate of about 10^3 amperes.

Calculate the electric charge carried by the Earth. It is possible to solve this problem in two equivalent ways.

When you are standing up, there is a potential difference of 200 volts between the top of your head and the ground. That is more than you need to be electrocuted! What is wrong? The explanation is that the current density in the atmosphere is only of the order of 10^{-12} ampere/meter^2, and the conductivity of a living organism is high. So the voltage difference across your body is less than what you could feel by very many orders of magnitude. See *Physics Today*, May 1999, pp. 15, 68.