4.26 Consider a charge q halfway between two grounded conducting plates. The electic field can be calculated by the image method, with an infinite number of images. On the midplane the field points away from q, by symmery. Using Mathematica plot the contribution to the electric field from the images charges (i.e., the full field minus the Coulomb field of the real charge) on the midplane, as a function of the distance from q. At what point on the midplane is the field due to the conducting planes maximum in magnitude?

To do this, setup a coordinate system with q at the origin an dhte conducting plates parallel to the yz plane at $x = \pm$a. There are an infiinte number of images charges, which we can label q_n where n= ±1, ±2, ±3,... and $q_n = (-1)^n q$ is located at $x_n = 2\,\text{na}$.

The midplane is the yz plane, x=0. There, at a distance r from the origin, the electric field is

$$E_r = \frac{1}{4\pi\epsilon_0}\left\{\frac{q}{r^2} - \frac{2\,\text{qr}}{\left[r^2+(2\,a)^2\right]^{3/2}} + \frac{2\,\text{qr}}{\left[r^2+(4\,a)^2\right]^{3/2}} + \ldots\right\}$$

$$= \frac{q}{4\pi\epsilon_0 r^2} + \frac{2\,\text{qr}}{4\pi\epsilon_0}\sum_{n=1}^{\infty}\frac{(-1)^n}{\left[r^2+(2\,\text{na})^2\right]^{3/2}}$$

where the second term is the field due to the surface charge of the conducting plates. The figure below shows a graph of this field:

In[15]:=
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Plot[r Sum[2 (-1)^k/(r^2 + 4 k^2)^(3/2), {k, 1, 10}], {r, 0, 10}]
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Out[15]=