1a) Make a quantitative estimate (within a factor of 10, say) of how much charge is on a freshly charged tape. Use the actual Coulomb force law and your experience from the lab.

Gravitational force on tape about equal to electric force

\[ \frac{mg}{r^2} = \frac{q^2}{4\pi\varepsilon_0 r^2} \]

\[ q = \sqrt{4\pi\varepsilon_0 mg} \approx 10^{-9} C \]

b) How many electrons does this represent?

\[ N = \frac{q}{e} = \frac{10^{-9}}{1.6 \times 10^{-19}} \approx 6 \times 10^9 \]

2. Assume that the molecules on the surface of the tape are arranged in a regular array as shown, and that the distance between adjacent molecules is about 3.0 \times 10^{-10} m, as shown. Estimate how many molecules there are over the entire surface of your tape and what fraction of them have had an electron removed in the charging process.

\[ \# \text{molecules} \times \frac{\text{Tape area}}{d^2} \approx 10^{-4} \text{ m}^2 \times \left(3 \times 10^{-10}\right)^2 \approx 1.1 \times 10^{15} \]

\[ N = f(\# \text{molecules}) \]

\[ f = \frac{6 \times 10^9}{1.1 \times 10^{15}} \approx 5.4 \times 10^{-6} \]

3. The surface charge density \( \sigma \) for your tape is defined as \( \sigma = \) (total charge on the tape)/(total area of the tape). If the density of charge on the surface is greater than about 5.0 \times 10^{-5} C/m^2 the charges will exert electric forces on the neighboring air sufficient to trigger a spark in the air. How does the density of charge on your tapes compare with this density?

\[ \frac{Q}{A_{\text{total}}} = \frac{10^{-9}}{10^{-4}} \times 10^{-5} \text{ C/m}^2 \]