**Quiz 1: Electric fields and so forth**

Things:

\[ \vec{F}_{12} = k_e \frac{q_1 q_2}{r^2} \hat{r} = q_2 \vec{E}_1 \]

\[ \vec{E}_1 = \frac{\vec{F}_{12}}{q_2} = k_e \frac{q_1}{r^2} \hat{r} \]

\[ \vec{E} = k_e \sum_i \frac{q_i}{r_i^2} \hat{r}_i \rightarrow k_e \int \frac{dq}{r^2} \hat{r} = k_e \int \frac{\rho \hat{r}}{r^2} dV_o \]

1. Two thin rigid rods lie along the \( x \) axis, as shown below. Both rods are uniformly charged. Rod 1 has a length \( L_1 \) and a charge per unit length \( \lambda_1 \). Rod 2 has a length \( L_2 \) and a charge per unit length \( \lambda_2 \). The distance between the right end of rod 1 and the left end of rod 2 is \( L \).

Which expression below could give the electric force between the two rods? Circle your answer.

\[ \vec{F}_{12,\text{tot}} = k_e \lambda_1 \lambda_2 \left[ \frac{(L_2 + L) (L_1 + L)}{L (L + L_1 + L_2)} \right] \hat{x} \]  \hspace{2cm} (1)

\[ \vec{F}_{12,\text{tot}} = k_e \lambda_1 \lambda_2 \ln \left[ \frac{(L_2 + L) (L_1 + L)}{L (L + L_1 + L_2)} \right] \hat{x} \]  \hspace{2cm} (2)

\[ \vec{F}_{12,\text{tot}} = k_e \lambda_1^2 \ln \left[ \frac{L_1 + L}{L + L_1 + L_2} \right] \hat{y} \]  \hspace{2cm} (3)

\[ \vec{F}_{12,\text{tot}} = k_e \lambda_1 \lambda_2 \frac{L_1 + L_2}{(L_1^2 + L_2^2)^{3/2} + L^2} \hat{x} \]  \hspace{2cm} (4)

2. Suppose three positively charged particles are constrained to move on a fixed circular track. If all the charges were equal, an equilibrium arrangement would obviously be a symmetrical one with the particles spaced 120° apart around the circle. Suppose two of the charges have equal charge \( q \),
and the equilibrium arrangement is such that these two charges are 140° apart rather than 120°. What is the relative magnitude and sign of the third charge?

- larger than either \( q_1 \) or \( q_2 \) and positive
- smaller than either \( q_1 \) or \( q_2 \) and positive
- larger than either \( q_1 \) or \( q_2 \) and negative
- smaller than either \( q_1 \) or \( q_2 \) and negative

3. In the figure above, a point charge \( 1Q^+ \) is at the center of an imaginary spherical Gaussian surface and another point charge \( 2Q^+ \) is outside of the Gaussian surface. Point \( P \) is on the surface of the sphere. Which one of the following statements is true?

- Both charges contribute to the net electric flux through the sphere but only \( 2Q^+ \) contributes to the electric field at point \( P \).
- Only \( 1Q^+ \) contributes to the net electric flux through the sphere but both charges contribute to the electric field at point \( P \).
- Both contribute to the net electric flux through the sphere but only \( 1Q^+ \) contributes to the electric field at point \( P \).
- Only \( 2Q^+ \) contributes to the net electric flux through the sphere but both charges contribute to the electric field at point \( P \).
- Only \( 2Q^+ \) contributes to the net electric flux through the sphere and to the electric field at point \( P \) on the sphere.
- Only \( 1Q^+ \) contributes to the net electric flux through the sphere and to the electric field at point \( P \) on the sphere.
- I don’t know (this answer is worth 1/5 of full credit)
4. The sphere of radius $a$ was filled with positive charge at uniform density $\rho$. Then a smaller sphere of radius $a/2$ was carved out, as shown in the figure, and left empty. Which expression could give the expression for the electric field anywhere inside the cavity? The $\hat{y}$ direction is vertical, and $r$ is measured from the center of the large sphere. *Hint: if it is true anywhere inside the cavity, pick an easy example point. What superposition of simple charge distributions could give the one shown?*

- $\vec{E} = \frac{2ke\pi \rho}{r} \hat{y}$
- $\vec{E} = \frac{2ke\pi \rho a}{r^2} \hat{y}$
- $\vec{E} = \frac{2ke\pi \rho a}{3} \hat{y}$
- $\vec{E} = \frac{2ke\pi \rho r}{a} \hat{y}$