

Instructions: You have a total of 50 minutes to complete this test. Answer each question completely. In order to obtain full credit for the problems, **you must** supply sketches, words, and details (including all assumptions) showing clearly how you obtained your answer. Correct SI units must be provided for numerical answers where required.

Time Start _____ Time finish _____ pledged _____

Constants: $k=8.987 \times 10^9 \frac{\text{Nm}^2}{\text{C}^2}$; $\epsilon_0=8.854 \times 10^{-12} \frac{\text{C}^2}{\text{Nm}^2}$

[1] In order to obtain full credit for this problem, **you must** supply sketches, words, and details (including all assumptions) showing clearly how you obtained your answer.

A sphere of radius a has a uniform volume charge density per unit volume given by

$$\rho(r) = \frac{Q}{\pi a^4} r \quad \text{when a total charge } Q \text{ is placed on the sphere.}$$

(a) Find the **vector electric field**, \vec{E} **outside** the sphere of charge in terms of Q, a and r .

(b) Find the **vector electric field**, \vec{E} **inside** the sphere of charge in terms of Q, a and r .

(c) Show that the two solutions are the same at the surface of the sphere.

[2] An infinitely long wire along the z-axis has a uniform linear charge density per unit length given by $2\lambda_0$.

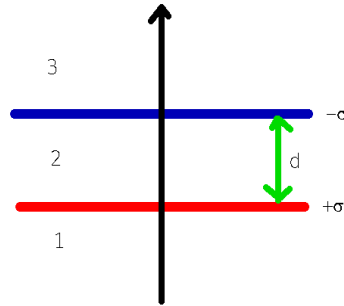
(a) Find the **vector electric field**, \vec{E} at a distance s from the wire. You should use for the cylindrical coordinate unit vector the symbol \hat{s} .

(b) Suppose that $\lambda_0 = 1 \frac{\mu\text{C}}{\text{m}}$. What is the **vector electric field** at a distance of 2000 m from the wire with correct SI units?

(c) If a charge $q_p = +3\mu\text{C}$ is placed 10 m from the wire, what is the **vector electric force** on the charge with correct SI units?

[3] An ideal parallel plate capacitor is in the x-y plane as shown. The capacitor is charged with a surface charge density $+\sigma$ on the plate located at $z=0$ and $-\sigma$ on the plate located at $z=d$.

(a) Make a sketch of the electric field, including electric field directions on the diagram below. You will need to use several lines here to correctly show this. In each of the 3 regions, use a double line arrow to represent fields from $+\sigma$ and use a single line arrow to represent the field from $-\sigma$.



(b) Find the **vector electric field**, \vec{E} between the plates of the capacitor (in region 2). You must show details and assumptions here (and a sketch).

(c) If $\sigma = 1 \times 10^{-10} \frac{\text{C}}{\text{m}^2}$. Find a numerical result for the **vector electric field** in region 2 with correct SI units.

[4] Two charges have the following coordinates: #1: $+q(+a,+a)$ and #2: $-q(-a,-a)$.

(a) Find the **vector electric field**, \vec{E} at the origin which has coordinates $(0,0)$ in terms of k,q , and a .

(b) If a charge q_p is placed at the origin, what is the **vector electric force** on this charge in terms of k,q,q_p , and a ?

(c) Provide a numerical result for the **vector electric force** with correct SI units on this charge for the case $a=1\text{m}$, and with both q_p and q given by $1\ \mu\text{C}$.