

Instructions: You have a total of 55 minutes to complete this test. Answer each question completely.

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. Correct SI units must be provided for numerical answers where required.

Time Start _____ Time finish _____ pledged _____

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

1. A sphere of radius a has a uniform charge distribution per unit volume given by $\rho = \rho_0 \left(\frac{r}{a}\right)$ where r is the distance from the center of the sphere and a is the radius of the sphere of charge.

(a) Find the **vector electric field**, \vec{E} inside the sphere.

(b) Find the **vector electric field**, \vec{E} outside the sphere.

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

2. An infinitely long wire has a linear charge distribution per unit length give by λ .

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

(b) Suppose that the charge distribution is given by: $\lambda = \frac{5\mu\text{C}}{\text{m}}$. What is the **vector electric field** at a distance of 10 m from the wire?

(c) If a charge $q_p = 7\mu\text{C}$ is placed 10 m from the wire, what is the **vector electric force** on the charge?

(3) An infinite plane with normal vectors along the $+z$ and $-z$ direction (i.e. the plane lies in the x - y plane) has a surface charge density given by σ .

(a) Find the **vector electric field**, \vec{E} at a distance $+z$ from the plane.

(b) If $\sigma = 5 \frac{\mu\text{C}}{\text{m}^2}$, find the **vector electric force** on a charge $q = -3\mu\text{C}$ which is placed 10 m from the plane.

(4) Two charges have the following coordinates: #1: $(-q; -a, 0, 0)$ and #2: $(+q; +a, 0, 0)$.

(a) Find the **vector electric field**, \vec{E} at a point y_p along the positive y axis which has coordinates $(0, y_p, 0)$.

(b) If a charge q_p is placed at y_p , what is the **vector electric force** on this charge?

(c) Provide a numerical for the electric force for the case $a=0.1$ m, $y_p=1.0$ m, q_p and $q=1\mu\text{C}$.