

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 _____

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

[1.] 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

$$\rho(r) = \frac{Q}{\frac{4}{3}\pi a^3} \quad \text{when a total charge } Q \text{ is placed on the sphere.}$$

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

(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 along the z-axis has a uniform linear charge density per unit length given by λ_0 .

(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: $\lambda = 15 \frac{\mu\text{C}}{\text{m}}$. What is the **vector electric field** at a distance of 10 m from the wire?

(c) If a charge $q_p = -4 \mu\text{C}$ 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 $+\sigma$.

(a) Make a sketch of the electric field, including directions. You will need to use several lines here to correctly show this.

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

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

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

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

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

(c) Provide a numerical result for the magnitude of the electric force on this charge for the case $a=0.1\text{m}$, $x_p=2.0\text{m}$, with q_p and q are $1\ \mu\text{C}$.