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

[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 $\rho(r)=5\frac{Q}{4\pi a^5}r^2$ when a total charge Q is placed on the sphere.

Note: you will need to integrate $4\pi\int\rho(r)r^2dr$ with appropriate limits in order to complete this problem.

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

(c) If a charge $q_p = -4 \mu C$ 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) 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 $\sigma = 10 \frac{\mu C}{m^2}$, find the **vector electric force** on a charge $q = 5 \mu C$ which is placed 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=0.1m, x_p=2.0m, with q_p and q are 1 μC.