

**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**,  $\vec{E}$  **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) Find the **electric potential** at the surface of the sphere where  $r=a$ .

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

**(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  $\hat{s}$ .

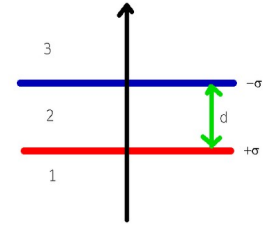
**(b)** Suppose that  $\lambda_0 = 1 \frac{\mu\text{C}}{\text{m}}$ . What is the **vector electric field** at a distance of 2000 m from the wire with correct SI units?

**(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?

**(d)** An electric potential varies as  $V(z) = bz$  in a region of space. Find the electric field associated with this potential.

**[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.

**(d)** If a sphere has a radius of 1 m, and has a charge  $Q$  placed upon it, find the capacitance of the sphere.

**(e)** Capacitors  $C_1$  and  $C_2$  are placed in series. Find the equivalent capacitance if  $C_1 = C_2$ .

**(f)** Capacitors  $C_1$  and  $C_2$  are placed in parallel. Find the equivalent capacitance if  $C_1 = C_2$ .

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

**(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  $1\ \mu\text{C}$ .

**(d)** Find the electric potential at the point (0,0).

**(e)** Find the vector electric dipole moment  $\vec{p}$  .