

**Instructions: You have a total of 55 minutes to complete this test.**

**Answer each question completely showing complete details.**

**For complete credit you must include correct SI units with numerical answers.**

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 charge  $q = 3\mu\text{C}$  is located at  $x=7$  and  $y=9$ .

**(1:a)** Find the **vector** electric field at the point  $p$ :  $x=3, y=11$ .

**(1:b)** If a charge  $q_p = -2\mu\text{C}$  is placed at  $p$ , find the **vector** electric force on  $q_p$ .

**(2)** A charge 1:  $[-2\mu\text{C}; 0, +1]$  and a charge 2:  $[+2\mu\text{C}; 0, -1]$  are located along the y-axis.

**(2:a)** Find the **vector** electric field along the positive x-axis at a point  $p:[5,0]$ .

**(2:b)** If a charge  $q_p=3\mu\text{C}$  is placed at  $p$ , find the **vector** electric force on  $q_p$ .

**(3)** A sphere of charge of radius  $a$  has a uniform volume charge density  $\rho = \frac{Q}{\frac{4}{3}\pi a^3}$  where  $Q$  is the total charge on the sphere.

**(3:a)** Find the **vector** electric field **inside** the sphere (showing complete details with sketches).

**(3:b)** Find the **vector** electric field **outside** the sphere (again, showing complete details with sketches).

**(4)** An infinite plane is located in the x-y plane at  $z=0$  and has a uniform surface charge density  $+\sigma$ . A second plane is located (parallel to the first) at  $z=+d$  and has a surface charge density  $-\sigma$ .

**(4:a)** Showing complete details, with sketches, find the **vector** electric field at  $z<0$  and  $z>d$ .

**(4:b)** Again, showing complete details, with sketches, find the **vector** electric field in the region  $z>0$  and  $z<d$ .

**(4:c)** Provide a numerical answer with correct SI units for the case that the surface charge density is  $\sigma = 3 \frac{\mu\text{C}}{\text{m}^2}$ .

4c:(a):  $E =$  \_\_\_\_\_

4c:(b):  $E =$  \_\_\_\_\_