

**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  $x=-3\text{m}$  and  $y=-5\text{m}$ .

**(1:a)** Find the **vector** electric field at the point  $p$ :  $x=3\text{m}, y=-11\text{m}$ .

**(1:b)** If a charge  $q_p=+5\mu\text{C}$  is placed at  $p$ , find the **vector** electric force on  $q_p$ .

**(2)** Consider two charges: 1:  $[-2\mu\text{C}; 1\text{m}, 1\text{m}]$  and 2:  $[+2\mu\text{C}; -1\text{m}, -1\text{m}]$ .

**(2:a)** Find the **vector** electric field at the point given by  $p: [-5\text{m}, 5\text{m}]$ .

**(2:b)** Provide a sketch of the electric field map showing direction and relative strength.

Note: one line here is completely insufficient.

**(2:c)** Find the **vector dipole moment** of the charge distribution with correct SI units.

**(3)** A sphere of total charge  $Q$  and of radius  $a$  has a uniform volume charge density given by  $\rho = Q / \left( \frac{4}{3} \pi a^3 \right)$ .

**(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 numerical answers **with correct SI units** for the case that the surface charge density is  $\sigma = 3 \mu\text{C}/\text{m}^2$ .

**4c:(a):**  $\vec{E}_{z < 0 \text{ or } z > d} =$  \_\_\_\_\_

**4c:(b):**  $\vec{E}_{z > 0 \text{ and } z < d}$  \_\_\_\_\_