

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 _____

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 is described by $q: [4\mu\text{C}; 2\text{m}, -8\text{m}]$.

(1:a) Find the **vector** electric field, $\vec{E}$ (with correct SI units) at the point p : $x=3\text{m}, y=5\text{m}$.

(1:b) Find the magnitude of the vector electric field, $|\vec{E}|$, with correct SI units.

(1:c) 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:[$-4\mu\text{C}$; -3m , 0m] and 2:[$+4\mu\text{C}$; $+3\text{m}$, 0m].

(2:a) Provide a sketch of the electric field map showing direction and relative strength.
Note: one line here is completely insufficient.

(2:b) Find the **vector** electric field at the point given by p:[0m , 5m].

(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 volume charge density given by $\rho = 2 \frac{Q}{\frac{4}{3}\pi a^3} \left(\frac{r}{a}\right)^3$. **Hint:** you will need to integrate $Q_{\text{enc}} = 4\pi \int \rho(r) r^2 dr$ with appropriate limits.

(3:a) Find the **vector** electric field **inside** the sphere (providing complete details with sketches). Express your answer in terms of Q , r and a , using the unit vector $\hat{r}$.

(3:b) Find the **vector** electric field **outside** the sphere (again, providing complete details with sketches). Express your answer in terms of Q and r using the unit vector $\hat{r}$.

(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 $\sigma=5\mu\text{C}/\text{m}^2$.

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

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