

Instructions: You have a total of 50 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 is described by $q: [-4\mu\text{C}; -6\text{m}, 3\text{m}]$.

(1:a) Find the **vector** electric field, \vec{E} (with correct SI units) at the point $p: x=-2\text{m}, y=5\text{m}$.

(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) An infinite plane is located in the x-y plane at $z=0$ and has a uniform surface charge density σ .

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

(2:b) Now consider a second plane which is located (parallel to the first) at $z=+d$ and has a surface charge density $-\sigma$. Showing complete details, **with sketches and words**, find the **vector** electric field between $z=0$ and $z=d$.

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

(3) Consider two charges: 1:[$2\mu\text{C}$;0m,3m] and 2:[$-2\mu\text{C}$;0m,-3m].

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

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

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

(4) A sphere of total charge Q of radius a has a volume charge density given by $\rho = \frac{Q}{\frac{4}{3}\pi a^3}$. At the center of the sphere, is an additional charge q .

(4:a) Find the **vector** electric field **inside** the sphere (providing complete details with sketches). Express your answer in terms of ϵ_0 , Q , q , r and a , using the unit vector \hat{r} .

(4:b) Find the **vector** electric field **outside** the sphere (again, providing complete details with sketches). Express your answer in terms of ϵ_0 , Q , q and r using the unit vector \hat{r} .