

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 _____

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 .

(1:d) Find the electric potential at the point p for the charge $q_p = +5\mu\text{C}$.

(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 uniform volume charge density given by

$$\rho = \frac{Q}{\frac{4}{3}\pi a^3} .$$

(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} .

(3:c) Find the electric potential at the surface of the sphere.

(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 in the region $z>0$ and $z<d$.

(4:b) Provide numerical answers **with correct SI units** for the case that the surface charge density is $\sigma=5\mu\text{C}/\text{m}^2$.

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

(4:d) what is the ratio of two $5\mu\text{f}$ connected in series to two $5\mu\text{f}$ capacitors connected in parallel?

(4:e) what is the ratio of two 10Ω resistors connected in series to two 10Ω resistors connected in parallel?

(4:f) A capacitor has a geometrical capacitance of $10\mu\text{f}$. A material with a dielectric constant $\kappa=3$ is inserted into the capacitor and completely fills the interior volume of the capacitor. What is the new capacitance?

(4:g) A $1\mu\text{f}$ capacitor has a potential difference of 100 V. What is the energy stored in the capacitor?