Physics 5C - First Midterm

Wednesday, April 23, 9-9:50AM

UCLA / Spring 2025 / Brian Naranjo

NAME ____________________

SIGNATURE ____________________

ID ____________________

- Wait until instructed to begin.
- This exam is closed-book, with no external notes and no external scratch paper.
- Use the back of this coversheet for scratch work. If needed, extra scratch paper is available.
- If your work continues on the scratch page, then make a note in your solution for the reader.
- You may unstaple your exam, but please keep the pages in order and include this coversheet.
- Only the following items are allowed at your seat: exam papers, pens, pencils, and photo ID.
- All backpacks, electronic devices (including calculators, watches, phones, etc.) must be placed at front of lecture hall.

Electric field

$$k = \frac{1}{4\pi\epsilon_0} \qquad |\mathbf{F}| = \frac{1}{4\pi\epsilon_0}\frac{|q_1 q_2|}{r^2}$$

$$\mathbf{E}(x,y,z) = \frac{\mathbf{F}_q(x,y,z)}{q}$$

$$|\mathbf{E}| = \frac{1}{4\pi\epsilon_0}\frac{|q|}{r^2} \qquad |\mathbf{E}| = \frac{1}{4\pi\epsilon_0}\frac{|Q_{\text{in}}(r)|}{r^2}$$

$$\sigma = Q/A \qquad |\mathbf{E}| = \frac{|\sigma|}{2\epsilon_0}$$

$$p = qd \qquad \tau = pE\sin\phi$$

$$\mathbf{E}_{\text{axis}} \approx \frac{1}{4\pi\epsilon_0}\frac{2\mathbf{p}}{r^3} \qquad \mathbf{E}_{\text{plane}} \approx -\frac{1}{4\pi\epsilon_0}\frac{\mathbf{p}}{r^3}$$

Electric potential

$$U = qV \qquad E_s \approx -\Delta V/\Delta s$$

$$V = \sum_i \frac{1}{4\pi\epsilon_0}\frac{q_i}{r_i} \qquad U = \frac{1}{4\pi\epsilon_0}\sum_{\text{all pairs}}\frac{q_i q_j}{r_{ij}}$$

$$V = -E_0 x \qquad U = -qE_0 x$$

$$U = -pE\cos\phi \qquad V = \frac{p\cos\theta}{4\pi\epsilon_0 r^2}$$

$$U_0 + K_0 = U_1 + K_1 \qquad 0 = \sum_{\text{loop}}(\Delta V)_i$$

Capacitance

$$Q = VC \qquad C_{\text{plate}} = \frac{\kappa\epsilon_0 A}{d}$$

$$U = \frac{Q^2}{2C} = \frac{QV}{2} = \frac{CV^2}{2} \qquad u_E = \frac{1}{2}\kappa\epsilon_0 E^2$$

$$C_p = C_1 + C_2 + \cdots \qquad 1/C_s = 1/C_1 + 1/C_2 + \cdots$$

$$E = E_0/\kappa \qquad C = \kappa C_0$$

Mechanics

$$v = v_0 + at \qquad x = x_0 + v_0 t + at^2/2$$

$$v^2 = v_0^2 + 2a(x - x_0) \qquad a_c = v^2/r$$

$$K = mv^2/2 \qquad W = F_x\,\Delta x = -\Delta U$$

Miscellaneous

$$\sin\theta = \frac{\text{opp}}{\text{hyp}} \quad \cos\theta = \frac{\text{adj}}{\text{hyp}} \quad \tan\theta = \frac{\text{opp}}{\text{adj}}$$

$$\cos 30^\circ = \sqrt{3}/2 \quad \cos 45^\circ = 1/\sqrt{2} \quad \cos 60^\circ = 1/2$$

$$\sin 30^\circ = 1/2 \quad \sin 45^\circ = 1/\sqrt{2} \quad \sin 60^\circ = \sqrt{3}/2$$

$$a^2 + b^2 = c^2 \;\; ; \;\; a^2 + b^2 - 2ab\cos\gamma = c^2$$

Sphere: $A = 4\pi r^2 \quad V = (4/3)\pi r^3$

Circle: $C = 2\pi r \quad A = \pi r^2$

$$ax^2 + bx + c = 0 \implies x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Charge : C

Electric field : N/C = V/m

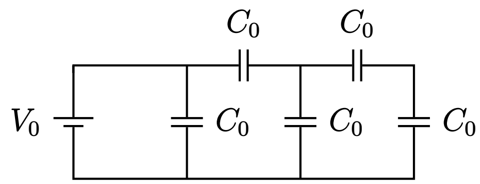
Electric potential : V = J/C

Capacitance : F = C/V

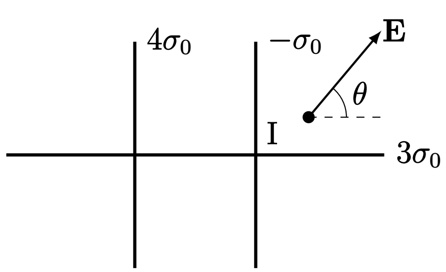
$\mathrm{M} = 10^6, \mathrm{k} = 10^3, \mathrm{m} = 10^{-3}, \mu = 10^{-6}$

ID ____________

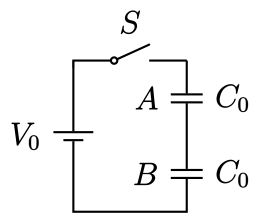
1) (25 points) Five capacitors, each of capacitance C_0, and a battery of emf V_0 are connected in the circuit shown. Find the total potential energy U_{net} stored in the capacitor network.



2) (25 points) Three uniformly-charged infinite planes are perpendicular to the plane of the paper, dividing space into six regions, as shown. Furthermore, the two vertical planes are perpendicular to the horizontal plane and charge density σ_0 is positive. In Region I, the electric field $\mathbf{E}$ is at an angle θ above the positive x direction. Find both the magnitude E and angle θ.



3) (25 points) Initially, switch S is closed so that battery V_0 charges the two parallel-plate capacitors, each of capacitance C_0, as shown. The switch is then opened and remains open. Finally, after *doubling* the gap on capacitor A and *tripling* the gap on capacitor B, find the final potential difference across each capacitor.



4) (25 points) An infinite plane of uniform positive surface-charge density σ_0 lies in the plane $x = 4a$, and a negative point charge $-q_0$ is fixed at the origin, as shown. A particle of mass m and positive charge q is released from rest at the point $(2a, 0)$ and moves along the x-axis. Find its speed v when it reaches the point $(a, 0)$.