PHYS1304 Mid Term A Name:____________________ ID: ____________________

This is the sheet for formulas and constants.

This exam is close-book with only a calculator allowed. Please write neatly in the problem sheets. Partial credits will be given only when your reasoning is clearly discernible from your writing. Each problem carries 20 points towards the total of 100 points for this exam.

Coulomb's Law $\vec{F} = k_e \frac{q_1 q_2}{r^2}\hat{r}$ or $\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$,

with $k_e = 8.99\times10^9\ \mathrm{N\cdot m^2/C^2}$, $\varepsilon_0 = 8.85\times10^{-12}\ \mathrm{C^2/N\cdot m^2}$

Gauss Law $\Phi_E = \oint \vec{E}\cdot d\vec{A} = \frac{q_{in}}{\varepsilon_0}$

Capacitance and Capacitor $C \equiv \frac{Q}{\Delta V}$ $C = \varepsilon_0 \frac{A}{d}$ $U_E = \frac{Q^2}{2C} = \frac{1}{2}C(\Delta V)^2$

$C_{eq} = C_1 + C_2 + \dots$, $\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$

Resistance, resistors and circuits $I \equiv \frac{dq}{dt}$ $J \equiv \frac{dI}{dA}$ $R = \frac{\Delta V}{I}$

$R = \rho\frac{l}{A}$ $\rho = \rho_0\left[1+\alpha\left(T - T_0\right)\right]$

$R_{eq} = R_1 + R_2 + \dots$

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$

$P = \Delta V\cdot I = I^2 R = \frac{(\Delta V)^2}{R}$

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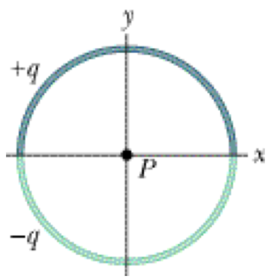
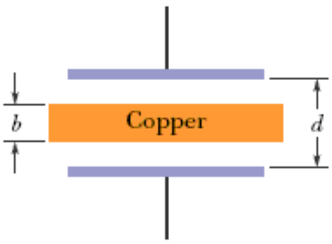
1. In the figure two curved plastic rods, one of charge $+q$ and the other of charge $-q$, form a circle of radius R = 10.0 cm in an xy plane. The x axis passes through both of the connecting points, and the charge is distributed uniformly on both rods. If q = 20.0 pC, what is the magnitude of the electric field produced at P, the center of the circle?

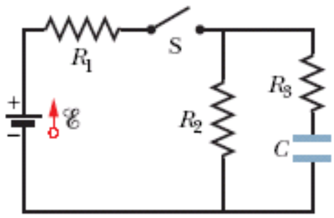


2. A slab of copper of thickness $b = 1.00$ mm is thrust into a parallel-plate capacitor of plate area $A = 100.00$ cm^2 and plate separation $d = 5.00$ mm, as shown in the figure; the slab is exactly halfway between the plates. **(a)** What is the capacitance after the slab is introduced? **(b)** If a potential difference $A = 24.0$ V is maintained between the plates, what is the ratio of the stored energy before to that after the slab is inserted? **(c)** How much work is done on the slab as it is inserted? **(d)** Is the slab sucked in or must it be pushed in?



3. A heating element is made by maintaining a potential difference of 60.0 V across the length of a Nichrome wire that has a $3.97 \times 10^{-6}\ m^2$ cross section. Nichrome has a resistivity of $5.00 \times 10^{-7}\ \Omega\cdot m$. **(a)** If the element dissipates 3600 W, what is its length? **(b)** If 120 V is used to obtain the same dissipation rate, what should the length be?

4. In the circuit the emf $= 2.0$ V, $C = 8.0\ \mu\text{F}$, $R_1 = R_2 = R_3 = 100\ \Omega$. Switch S is closed at $t = 0$. At $t = 0$, what are **(a)** current i_1 in resistor 1, **(b)** current i_2 in resistor 2, and **(c)** current i_3 in resistor 3? At $t = \infty$ (that is, after many time constants), what are **(d)** i_1, **(e)** i_2, and **(f)** i_3? What is the potential difference V_2 across resistor 2 at **(g)** $t = 0$ and **(h)** $t = \infty$?



5. In the figure the resistances are $R_1 = 10.0\ \Omega$ and $R_2 = 20.0\ \Omega$, and the ideal batteries have emfs $\varepsilon_1 = 2.0$ V, and $\varepsilon_2 = \varepsilon_3 = 4.0$ V. What are the **(a)** size and **(b)** direction (up or down) of the current in battery 1, the **(c)** size and **(d)** direction of the current in battery 2, and the **(e)** size and **(f)** direction of the current in battery 3? **(g)** What is the potential difference $V_a - V_b$?