PHYS 205-Section 03
Midterm Exam
Time: 120 min

Short answers

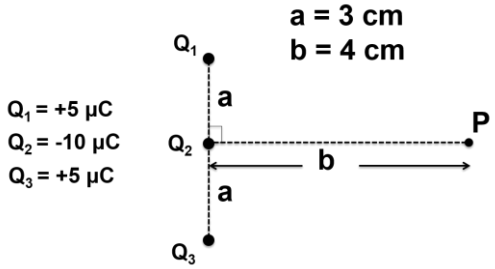
1. The electric force between two positively charged particles q_1 and q_2, which are at a distance r from one another, has a magnitude of F.
   a) Draw a sketch showing the direction of the force applied on each particle and write the relationship between these forces ($\vec{F}_{12}$ and $\vec{F}_{21}$). Use vector notation and clearly describe your answer. **(2 points)**
   b) If we double the magnitude of each charge, as well as the distance between them, find the force between them in this new configuration, in terms of F. **(2 points)**

2. If a positively charged irregular shaped conductor is in static equilibrium,
   a) What should be the electric field inside it? Why? **(2 points)**
   b) What should be its charge distribution? (where will the charges go?) Explain. **(2 points)**
   c) Draw a sketch of the electric field of this conductor and briefly comment on the direction of the electric field. **(2 points)**

3. If we fully charge a parallel plate capacitor (with no dielectrics between its plates), disconnect it from the battery, and then put a dielectric with constant $k > 1$ in between the plates, what happens to (a) the charge stored in the capacitor **(2 points)** and (b) the potential difference between the two plates? **(2 points)** Briefly explain.

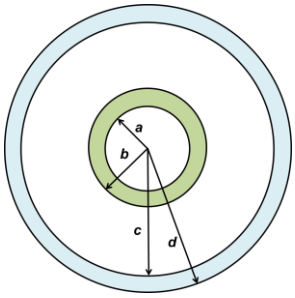
Problems

1. In the system of charges below:
   a) find the electric field at point P. **(3 points)**
   b) find the electric potential at point P. **(2 points)**



2. A proton with $m = 1.7 \times 10^{-27}\ kg$ and charge $+e$ is moving with speed of $v = 10^6\ \left(\frac{m}{s}\right)$ from a very far distance towards a gold nucleus with charge $+79e$. How close can the proton get to the gold nucleus? $e = 1.6 \times 10^{-19}\ C$. **(4 points)**

3. An insulating spherical shell of charge $q = -1$ μC (uniform volume charge distribution ρ) is placed inside a conducting spherical shell with charge $Q = +2$ μC.
   a) Find the electric field at $b < r < c$ **(3 point)**
   b) Find the charge on the inner and outer surface of the conducting shell. **(2 point)**



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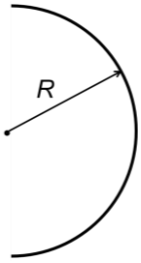
4. Find the electric potential (V) at the center of a uniformly charged semicircular rod with linear charge density λ and radius R. Show your work clearly. **(4 points)**



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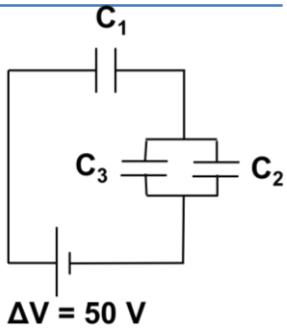
5. In the configuration below, $C_1 = C_2 = 2C_3 = 4\ \mu F$.
   a) Find the charge stored on each capacitor **(2 points)**
   b) Find the potential difference across each capacitor **(2 points)**
   c) How much would the total energy stored in the capacitors change if we put the whole circuit in oil with dielectric constant of $k = 5$? What is the physical meaning of this change in total energy? **(2 points)**



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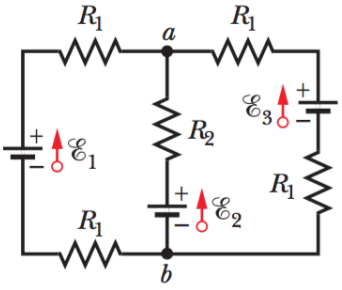
6. In the figure, $R_1 = 1\ \Omega$ and $R_2 = 2\ \Omega$, and the ideal batteries have emf of $\mathcal{E}_1 = 2\ V$ and $\mathcal{E}_2 = \mathcal{E}_3 = 4\ V$. Determine: (a) The current passing through each resistor **(3 points)**, (b) total power delivered by the batteries **(1 point)**, (c) the potential difference between points *a* and *b*. **(2 points)**
   Note: The red arrows do not necessarily show the direction of currents in the branches.



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7. In the circuit, $\mathcal{E} = 1.2\ kV$, $C = 6.5\ mF$, $R_1 = R_2 = R_3 = 1\ M\Omega$. With C completely uncharged, switch S is suddenly closed (at $t = 0$). Determine: (a) at $t = 0$, the current I_1 in resistor 1, current I_2 in resistor 2, and current I_3 in resistor 3? **(3 points)**
   (b) After a very long time ($t \to \infty$), what are I_1, I_2, and I_3? Describe your answer. **(2 points)**