MIDTERM PRACTICE SET

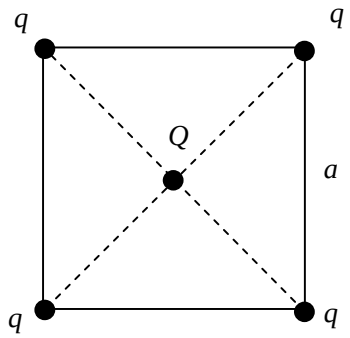
This is the problem practice set for PHY102 MIDTERM EXAM; this problem set covers the essential topics and problems that can be given on your midterm exam. This does not mean that the problems will be the same. It means that if you can solve these problems yourself, you likely will be able to answer all practical questions on the exam. This is also your compulsory homework to be submitted during your next regular lecture.

The midterm exam will consist of 5 to 10 questions, both practical and theoretical. Any topic, example, or proof from the lectures can appear on the theoretical part. Since the material given in the class did not correspond strictly to your textbook, you should use the class notes during your preparations for the exam.

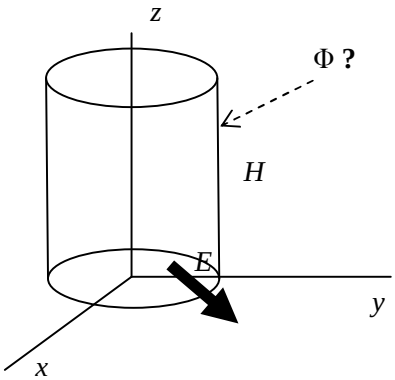
According to the exam rules, you will be allowed to bring two two-sided A4 papers of any *hand-written notes*: **no photocopies of any kind will be allowed**. No books or notebooks will be allowed. You can bring a separate calculator, but you will not be able to use the calculator in your cell phone. You can bring and use a dictionary.

Problem 1: Five charges are arranged as shown; q=1μC, Q=-1μC, and a=10cm.

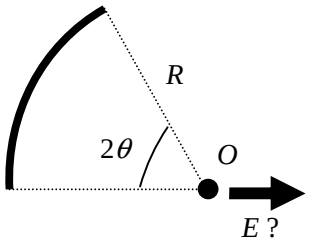
(a) Determine the electrical forces (magnitude and direction) applied to all charges.
(b) Calculate the electric potential at the center of the square.
(c) Calculate the electric potential energy of this system of charges.



Problem 2: Consider an empty (empty means there are no electric charges inside) cylinder of height H, as shown below. Calculate the flux of the electric field $\vec{E}(x, y, z) = (2x, y, -3z)$V/m through the *side surface* of this cylinder.



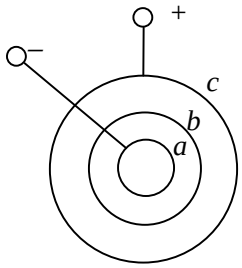
Problem 3: A circular arc of radius R and angle 2θ, as shown, is uniformly charged with linear density k. Determine the electrical field (magnitude and direction) at the center of the arc, point O.



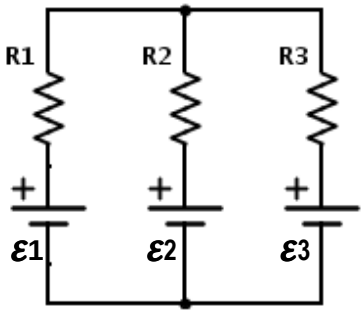
Problem 4: Consider a solid metal sphere of radius R=0.1m.

a. Calculate the capacitance of this sphere C.
b. Assuming there is on average a 150V/m electric field in the air near to the ground and the mass of the sphere is 500 gram, what electrical charge should be given to the sphere to let it "float" above the ground?
c. What potential should be applied to the sphere to give it that charge?

Problem 5: A spherical capacitor is made from three metal spheres of radii a, b, and c, as shown. Find the capacitance of this capacitor.

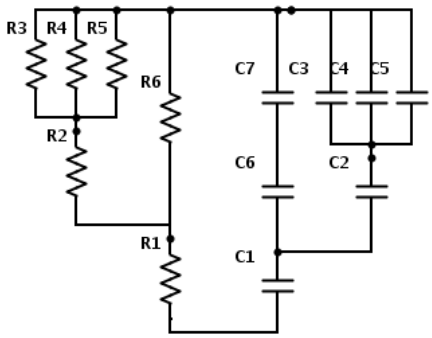


Problem 6: Consider electric circuit below with batteries $\mathcal{E}_1$=1V, $\mathcal{E}_2$=2V, and $\mathcal{E}_3$=3V, and resistances R_1=10Ω, R_2=20Ω, and R_3=30Ω. Find the currents and potential differences on each resistance.

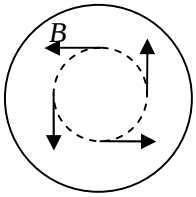


Problem 7: Calculate the attractive force (in Newtons) between two plates of a parallel plate capacitor with capacitance C=100nF, stored charge Q=1μC, and distance between plates d=1mm.

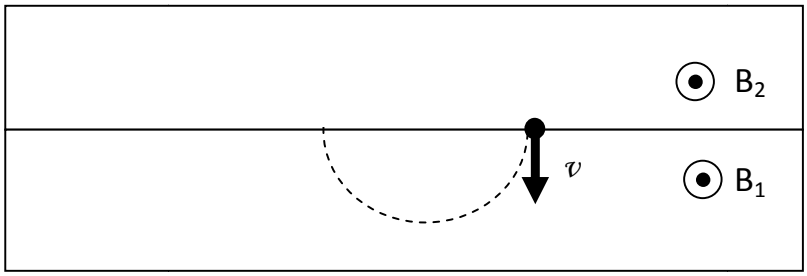
Problem 8: Consider the electric circuits below. Find the total resistance and the total capacitance in that circuit. Assume all resistances are R and all capacitances are C



Problem 9: Inside a metal cylinder of radius R the magnetic field was measured to be cylindrically symmetric (as shown below) and change with distance from the cylinder's axis r as $B=ar^2$. Use Ampere's law to calculate the current density inside this cylinder as a function of r. What is the total current through the cylinder? What is the direction of the current (into the page or out of the page)?



Problem 10: A particle with positive charge q is moving with speed v between two regions with magnetic fields $B_1 > B_2$ as shown. Describe the motion of the particle. In which direction and with what speed the particle will move on average?



Problem 11: A charge Q=-1μC is placed at point $\vec{X} = (0,0,0)$ inside a dielectric material with dielectric permittivity ε=3. What polarization density vector $\vec{P}$ is induced in the dielectric by this charge? What additional electric field is created by this polarization?