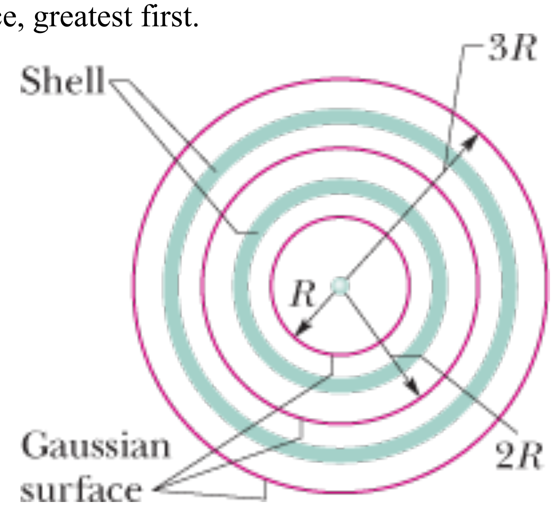
Homework 4: Hard-Copy Homework Due Wednesday 2/17

Special instructions for this homework: Please show all work necessary to solve the problems, including diagrams, algebra, calculus, or whatever else may be needed. For the first five concept questions (1-5) write at least a sentence justifying your answer. You will need to turn in this homework in paper form, with your name on it, either in person in class Wednesday, or under my office door (414 Van Allen) by 11pm Wednesday night.

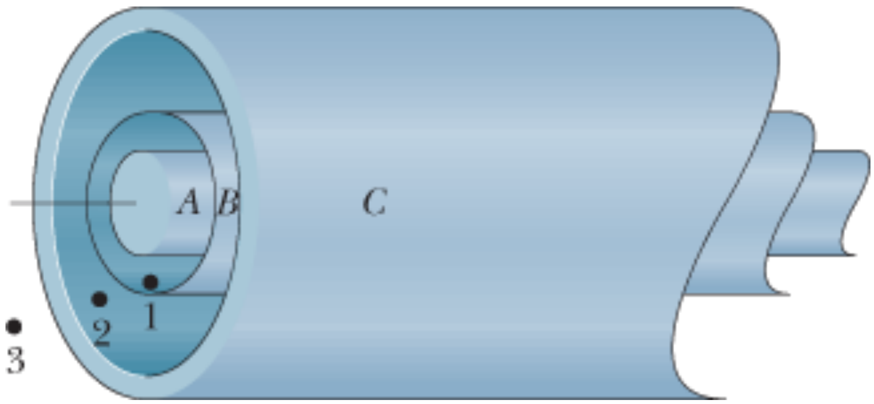
Note: This homework will be graded just like the midterm. The midterm will look very similar in format, but will ask for answers in algebraic form rather than requiring explicit computation (no calculator needed). Thus, it is recommended that you practice by working out these problems algebraically as far as possible before plugging in any numbers.

Question 1:

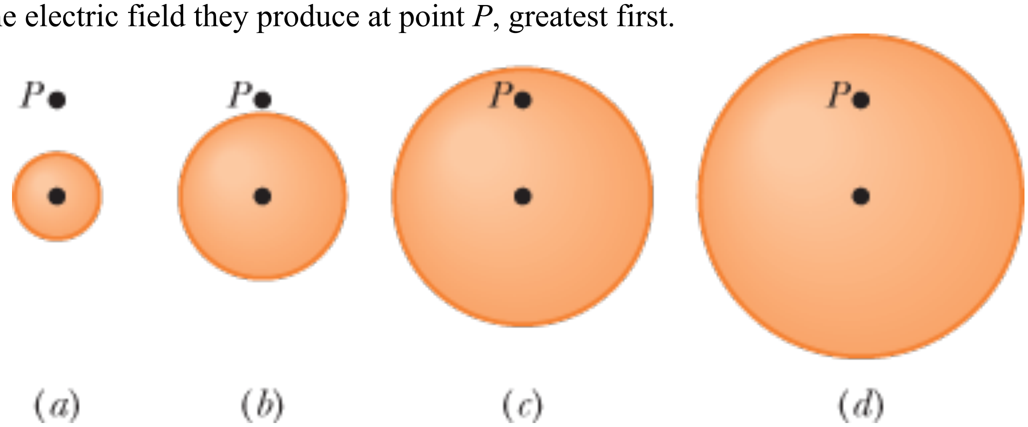
The figure below shows shows, in cross section, a central metal ball, two spherical metal shells, and three spherical Gaussian surfaces of radii R, $2R$, and $3R$, all with the same center. The uniform charges on the three objects are: ball, Q; smaller shell, $3Q$; larger shell, $5Q$. Rank the Gaussian surfaces according to the magnitude of the electric field at any point on the surface, greatest first.



Question 2: The figure below shows a section of three long charged cylinders centered on the same axis. Central cylinder *A* has a uniform charge $q_A = +3q_0$. What uniform charges q_B and q_C should be on cylinders *B* and *C* so that (if possible) the net electric field is zero at (a) point 1, (b) point 2, and (c) point 3? If it is impossible to make the field zero at one of these points, state that as well, and explain why.

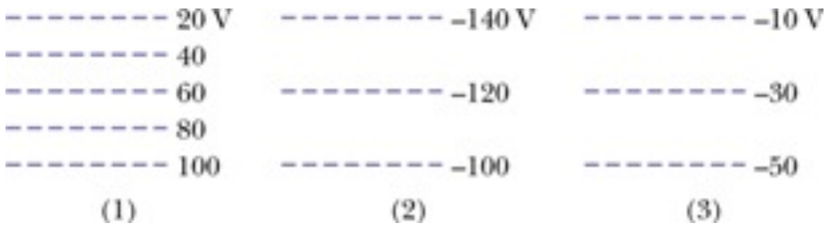


Question 3: The figure below shows four solid spheres, each with charge *Q* uniformly distributed through its volume. (a) Rank the spheres according to their volume charge density, greatest first. The figure also shows a point *P* for each sphere, all at the same distance from the center of the sphere. (b) Rank the spheres according to the magnitude of the electric field they produce at point *P*, greatest first.



Question 4:

The figure shows three sets of cross sections of equipotential surfaces; all three cover the same size region of space.

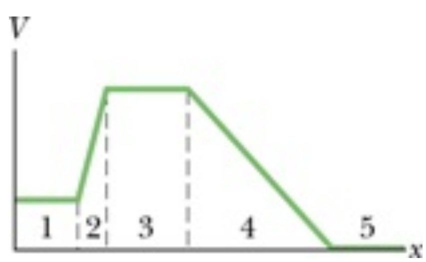


Rank the arrangements according to the magnitude of the electric field present in the region, greatest first. If multiple arrangements rank equally, use the same rank for each, then exclude the intermediate ranking (i.e. if objects A, B, and C must be ranked, and A and B must both be ranked first, the ranking would be A:1, B:1, C:3). If all arrangements rank equally, rank each as '1'.

In which is the electric field directed down the page? (Several choices may be correct.)

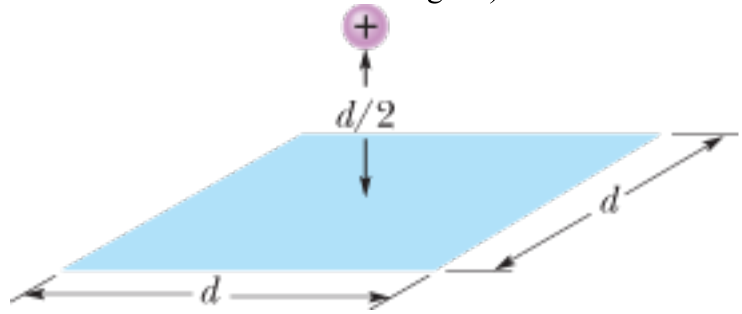
Question 5:

The figure gives the electric potential V as a function of x.

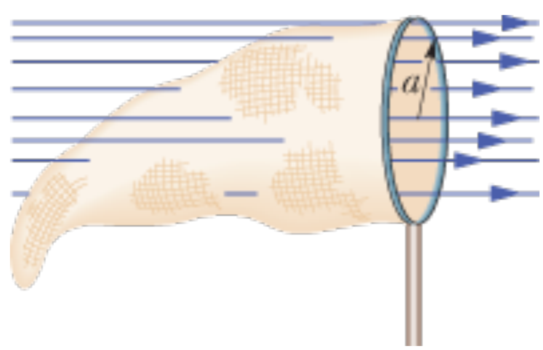


Rank the five regions according to the magnitude of the x component of the electric field within them, greatest first. If multiple arrangements rank equally, use the same rank for each, then exclude the intermediate ranking (i.e. if objects A, B, and C must be ranked, and A and B must both be ranked first, the ranking would be A:1, B:1, C:3). If all arrangements rank equally, rank each as '1'.

Question 6: In the figure below, a proton is a distance $d/2$ directly above the center of a square of side *d*. What is the magnitude of the electric flux through the square? (*Hint*: Think of the square as one face of a cube with edge *d*.)

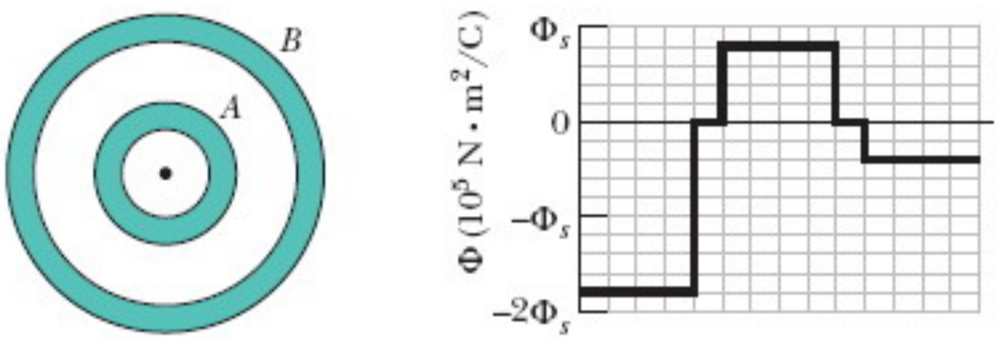


Question 7: In the figure below, a butterfly net is in a uniform electric field of magnitude $E = 3.0\ \mathrm{mN/C}$. The rim, a circle of radius $a = 11\ \mathrm{cm}$, is aligned perpendicular to the field. The net contains no net charge. Find the electric flux through the netting.



Question 8:

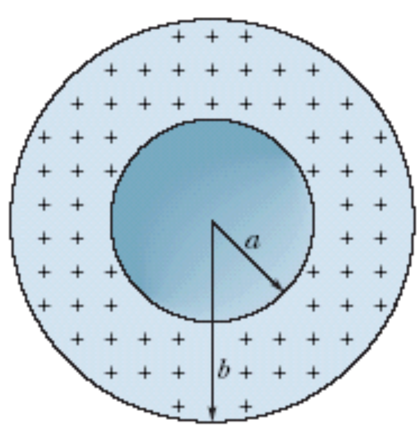
A charged particle is held at the center of two concentric conducting spherical shells. Figure (a) shows a cross section. Figure (b) gives the net flux Φ through a Gaussian sphere centered on the particle, as a function of the radius r of the sphere. The scale of the vertical axis is set by $\Phi_s = 2.5 \times 10^5$ N·m^2/C. What are **(a)** the charge of the central particle and the net charges of **(b)** shell A and **(c)** shell B?



(a) (b)

Question 9:

The figure shows a spherical shell with uniform volume charge density $\rho = 2.09$ nC/m^3, inner radius $a = 9.00$ cm, and outer radius $b = 2.8a$. What is the magnitude of the electric field at radial distances **(a)** $r = 0$; **(b)** $r = a/2.00$, **(c)** $r = a$, **(d)** $r = 1.50a$, **(e)** $r = b$, and **(f)** $r = 3.00b$?



Question 10:

Two large, parallel, conducting plates are 17 cm apart and have charges of equal magnitude and opposite sign on their facing surfaces. An electrostatic force with a magnitude of 3.9×10^{-15} N acts on an electron placed anywhere between the two plates. (Neglect fringing.) **(a)** Find the electric field at the position of the electron. **(b)** What is the potential difference in volts between the plates?