Phy 212 – Spring 2003

Name .....

Please write your name on the preceding line and **circle your workshop section** (TA name and time). The exam is closed book and notes. Work all problems on these pages. Show all work to obtain full credit.
Good luck!

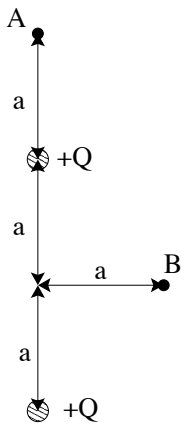
Drenchko/Fitzgibbons: 8:30 9:35 10:40
Eric West: 10:40 11:45 12:50
Maxim Marchevsky: 1:55
Alphonso Magri: 11:45

Exam 1

By submitting this exam, I pledge that I have not given nor received any unauthorized assistance.

Problem 1.

Consider the arrangement of two positive charges shown in the figure.
Give your answers below in terms of Q, a, and universal constants.
Choose a coordinate system and indicate the direction of any vector with respect to this coordinate system.



(a) What is the electric force (magnitude and direction) experienced by the upper charge?

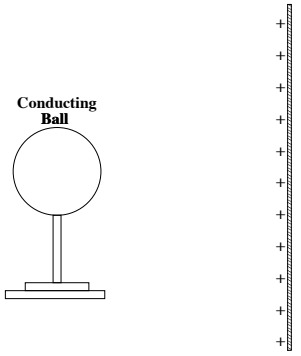
(b) Calculate the electric field vector at point A.

(c) Calculate the electric field vector at point B.

Problem 2

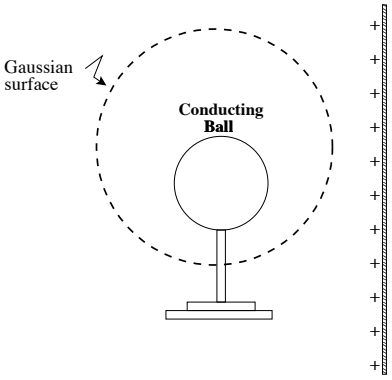
An **uncharged conducting** ball is brought near the center of a large plane carrying a uniformly distributed positive charge of density $\sigma > 0$. The ball is supported by an insulating stand.

(a) Indicate on the figure the charge distribution on the ball.



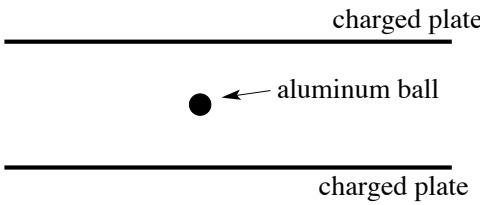
(b) Sketch the electric field lines in the region of space between the ball and the plane.

(c) The cross section of a spherical Gaussian surface that completely encloses the ball is shown below as a dashed line. What is the total electric flux through this Gaussian surface?



(d) A rubber rod rubbed with fur acquires a negative charge, while a glass rod rubbed with silk acquires a positive charge. In a classroom demonstration you observed that both such rubbed rods repel a neutral soda can. Explain why this happens.

Problem 3
A light aluminum ball of mass $m = 40$ g carrying a positive charge $q = 5$ nC is placed in the region between two large oppositely charged parallel plates, as shown. The ball is observed to float between the plates.



(a) Draw a free body diagram for the ball, identifying clearly all the forces that must be acting on it.

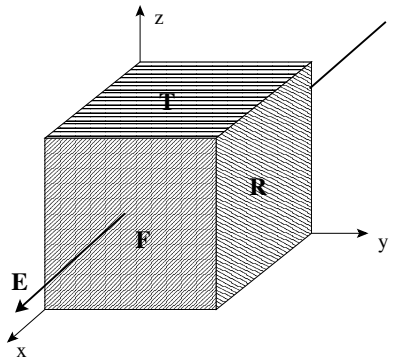
(b) Find the magnitude of the electric field that must be present in the region between the plates.

(c) Find the direction that this electric field must have. Show the electric field lines on the figure above and indicate the sign of the charge on each plate.

(d) **Extra credit question.**
The magnitude of the charge density on each plate is suddenly doubled, therefore doubling the magnitude of the electric field in the region between the plates. Describe the subsequent motion of the ball.

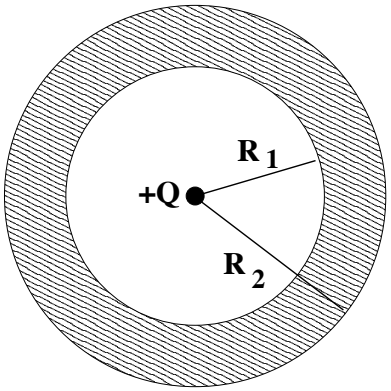
Problem 4

(a) The edge of the cube shown is $a = 2$ m. The cube is in a region of uniform electric field of strength 5×10^4 N/C. The electric field is directed along the x axis. Find the electric flux through each of the three faces of the cube labeled F, T and R.



(b) A point charge $q = -6 \times 10^{-6}$ C is placed at the center of the cube. What is the net flux through the cube?

(c) A hollow spherical conductor of inner and outer radii R_1 and R_2, respectively, carries a total negative charge $-3Q$, where $Q > 0$. A positive point charge $+Q$ is placed at the center of the spherical cavity. Electrostatic equilibrium has been established.



(i) What is the total charge on the inner and on the outer surface of the conductor?

(ii) What is the electric field inside the conducting shell (i.e., in the shaded region of the figure above)?

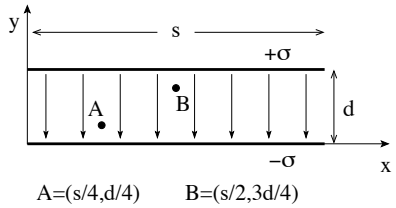
(iii) Use Gauss' Law to find the electric field (magnitude and direction) outside the conductor, at a distance $r > R_2$ from the center of the shell. Indicate clearly your choice of Gaussian surface.

Problem 5

(a) The large metal globe of a Van der Graaff generator has an electrostatic potential of 2×10^5 Volts relative to "ground" (here the small sphere that is used to discharge the large globe). The large globe has radius 0.5 m.
How much work is required to transfer an additional charge of 2×10^{-9} Coulomb from the "ground" to the globe?

(b) After charging the globe of the Van der Graaff generator, the motor is switched off and the small grounded metal sphere is brought in contact with the large globe. How do the potentials of the globe and the grounded sphere compare after the spark has occurred and the two conductors have reached electrostatic equilibrium?

(c) Two large parallel conducting plates separated by a distance d carry equal but opposite charges on their facing surfaces. The magnitude of the charge density on each plate is σ. A uniform electric field of magnitude $|\vec{E}| = \sigma/\epsilon_0$ and direction as indicated in the figure exists in the region between the plates.



A positive charge q moves from A to B. What is the change in its potential energy?