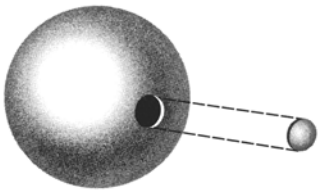
SNU Physics 2016 Spring Semester Physics 2: Problem Set #2

1. Consider the following geometrical shapes in which a point charge q is situated.
   a) charge q at the center of a cube with edge length of a. Express the electric flux through its faces.
   b) charge q at the center of the base of a pyramid (four equilateral triangles and a square base of side length a). Express the electric flux emerging from one of the equilateral triangles.

2. Consider the following uniformly charged (σ) objects with an empty small hole of radius r.
   a) infinite sheet: Express $\boldsymbol{E}$ at point P which lies on a line perpendicular to the sheet and intersects the center of the circular hole.
   b) spherical shell: Express $\boldsymbol{E}$ at the center of the empty hole (see image on the right).



3. Consider two oppositely charged (σ and -σ) strips (both with width b and negligible thickness).
   a) Express $\boldsymbol{E}$ due to one of the strips at a point on the same plane as the strip distance x from it (assume length of the strip >> b).
   b) Show that the force (per unit height) between the two strips can be expressed as $F/l = \sigma^2 b(\ln 2)/\pi\epsilon_o$.

4. Consider a ring of radius R, which is uniformly positively charged with a line charge density of λ. A particle of charge $+q$ and mass m is free to move in the same plane as the ring. Initially, it is at the center of the ring. Then, it is moved by a small distance r from the center. Show that the particle undergoes a simple harmonic oscillation and express its frequency. (Hint: find $U(r)$ for small r. Then, the force (restoring) is $F = -\frac{dU}{dr}$)

5. Consider a very long cylinder with radius b which is uniformly charged with Q and an equally long rod with radius a which is uniformly charged with $-Q$. And, $b > a$.
   a) Express $\boldsymbol{E}$ as a function of distance r from the central axis along the length of the cylinder (without the rod)
   b) Now, the rod is inserted into the cylinder so central axis of the rod and cylinder overlap. Express $\boldsymbol{E}$ as a function of distance r from the common central axis of the rod and cylinder.
   c) How much work was done to insert the rod into the cylinder? List various ways that this value can be calculated.

6. Consider a spherical thick shell
   a) Charge Q is uniformly distributed throughout its volume with an inner radius of R_1 and an outer radius of R_2. Express $\boldsymbol{E}$ as function of r, for $0 \leq r \leq \infty$.
   b) For $R_2 = 2R_1$, Find V at the center of the shell.

7. Consider a square sheet with a uniform charge density σ. With $V = 0$ for infinite distance from the square, V_o denotes the potential at the center of the square and V_1 at the corners. Find the ratio V_o/V_1.

8. Consider a uniformly charged (σ) disk with radius a. Express the potential at a point which is at the rim (edge) of the disk.

9. The capacitance of two conducting parallel plates separated by distance s is given as C. What is the capacitance if a third plate is inserted between the two plates and the two original plates are connected by a wire?

10. A capacitor consists of three concentric spherical shells with radii R, $2R$, $3R$. The inner and outer shells are connected by a wire so that they are at the same potential. Initially the three shells are neutral.
   a) Then, the middle shell is charged (i.e., by a battery) with $-Q$. What are the charges on the inner and outer shell?
   b) What is the capacitance of the system?