Physics 260 Homework Solution 10

Chapter 24

1 PSE6 24.P.003

The maximum flux is found when the loop of diameter d is perpendicular to the direction of the electric field. Therefore, $E = \Phi_e/A = 4\Phi_e/\pi d^2$.

2 PSE6 24.P.004

a. $\Phi_e = EA\cos\theta = E(.1\text{m})(.3\text{m})\cos 180°$
b. use the same equation used in part (a) with $A = (.3\text{m})\sqrt{(.3\text{m})^2 + (.1\text{m})^2}$ and $\theta = 60°$.

c. Since it is a closed surface, the net electric flux through the entire surface of the box is 0 (there are same amount of electric field lines enterning and leaving the box).

3 PSE6 24.P.009

a.

$$\Phi_e = \frac{q_{\text{in}}}{\epsilon_0} = \frac{q_1 + q_2 + q_3 + q_4}{\epsilon_0}$$

b. Since the net charge is negative, there are more electric field lines entering the submarine than leaving it.

4 PSE6 24.P.020

The magnitude of the electric field is the same on the surface of the sphere. And direction of the electric field is the same as the normal to the surface. Therefore,

$$\Phi_{E,hole} = EA_{hole} = \frac{k_e Q}{R^2}(\pi r^2)$$

where R is the radius of the hollow sphere and r is the radius of hole.

5 PSE6 24.P.024

Since the charges are uniformly distributed throughout the sphere, charge density ρ, amount of charge per unit voulume, equals the total charges in the sphere divided by the total volume,

$$\rho = \frac{Q}{V} = \frac{Q}{\frac{4}{3}\pi R^3}$$

where R is the radius of the sphere.
a. $E = 0$ since $q_{\text{in}} = 0$.
b.

$$\int E \mathrm{d}A = \frac{q_{\text{in}}}{\epsilon_0}$$

$$E 4\pi r^2 = \frac{\rho \frac{4}{3}\pi r^3}{\epsilon_0}$$

Solve for E.
c. Use the same approach as part (b) except now $r = R$.

d.

$$E 4\pi r^2 = \frac{Q}{\epsilon_0}$$

Again, solve for E.

6 PSE6 24.P.031

a. $E = 0$ since $q_{\text{in}} = 0$ for $r > R$ where r is the distance from the center and R is the radius of the spherical shell.

b.

$$\int E \mathrm{d}A = \frac{q_{\text{in}}}{\epsilon_0}$$

$$E(4\pi r^2) = \frac{Q}{\epsilon_e}$$

$$E = \frac{Q}{4\pi\epsilon_e r^2}$$

7 PSE6 24.P.036

a. The charge distribution density ρ is

$$\rho = \frac{\text{total charge}}{\text{total volume}} = \frac{Q}{\frac{4}{3}\pi R^3}$$

where R is the radius of the sphere. The volume enclosed by the concentric spherical surface is $\frac{4}{3}\pi r^3$. And the amount of charges enclosed by this surface is then

$\rho \times (\frac{4}{3}\pi r^3)$.

b. Since the given radius is bigger than the actual radius of the sphere, the total charge enclosed is all the charge on the sphere.

8 PSE6 24.P.039

$$\int E\mathrm{d}A = E(2\pi r l) = \frac{q_{in}}{\epsilon_0}$$

$$E = \frac{q_{in}}{l}\frac{1}{2\pi\epsilon_0 r} = \frac{\lambda}{2\pi\epsilon_0 r}$$

where λ is charge per unit length.

9 PSE6 24.P.040

We can consider the ground to be a conducting sheet with infinite area. So $E = \sigma/\epsilon_0$ where σ is the surface charge dentsity.

10 PSE6 24.P.043

a. Once the copper with side a plate is placed in the uniform electric field, positive charges and negative charges will separate and reside on two faces of the metal plate. Using expression $E = \frac{\sigma}{\epsilon_0}$ to find out σ for one of the faces. The other face should have same magnitude for the surface charge density but with opposite sign.
b.

$$q = \sigma A = \sigma a^2$$

11 PSE6 24.P.044

Suppose the solid conduction sphere has charge q_1, then the inner spherical shell surface has charge $q_2 = -q_1$. And the outer spherical shell surface has charge $q_3 = q_{net} - q_2$.

a. $E = 0$ since $q_{\text{in}} = 0$.

b.

$$E(\pi r^2) = \frac{q_1}{\epsilon_0}$$

$$E = \frac{q_1}{\pi r^2 \epsilon_0}$$

c. Use the same approach as part (b). Now $q_{\text{in}} = q_1 + q_2 = 0$. Therefore

$E = 0$.

d. Use the same approach as part (b). Now $q_{\text{in}} = q_1 + q_2 + q_3$.

12 PSE6 24.QQ.001

The flux remains the same ans the electric field increases.

13 PSE6 24.QQ.002

The requirement does not exist since the total electric flux is zero no matter what.

14 PSE6 24.QQ.004

q_2 & q_3.

15 PSE6 24.QQx.004

$q_1 = -Q$, $q_2 = +Q$, and $q_3 = +Q$