## Homework for Chapter 23

(Due 9/22/22)

Questions: 4, 6, 8
Exercises \& Problems: 2, 12, 19, 26, 31, 39, 41, 49, 76

## Question 4

Figure 23-22 shows, in cross section, two Gaussian spheres and two Gaussian cubes that are centered on a positively charged particle. (a) Rank the net flux through the four Gaussian surfaces, greatest first. (b) Rank the magnitudes of the electric fields on the surfaces, greatest first, and indicate whether the magnitudes are uniform or variable along each surface.


## Question 6

Three infinite nonconducting sheets, with uniform positive surface charge densities $\sigma, 2 \sigma$, and $3 \sigma$, are arranged to be parallel like the two sheets in Fig. 23-17a. What is their order, from left to right, if the electric field $\vec{E}$ produced by the arrangement has magnitude $E=0$ in one region and $E=2 \sigma / \varepsilon_{0}$


## Question 8

Figure 23-25 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.


## Problem 2

An electric field is given by $\vec{E}=4.0 \mathrm{i}^{\wedge}-3.0\left(y^{2}+2.0\right) \mathrm{j}^{\wedge}$ pierces a Gaussian cube of edge length 2.0 m and positioned as shown in Fig. 23-5. (The magnitude $E$ is in newtons per coulomb and the position $x$ is in meters.) What is the electric flux through the (a) top face, (b) bottom face, (c) left face, and (d) back face? (e)What is the net electric flux through the cube?

The y component



## Problem 12

Figure 23-32 shows two non-conducting spherical shells fixed in place. Shell 1 has uniform surface charge density $+6.0 \mu \mathrm{C} / \mathrm{m}^{2}$ on its outer surface and radius 3.0 cm ; shell 2 has uniform surface charge density $+4.0 \mu \mathrm{C} / \mathrm{m}^{2}$ on its outer surface and radius 2.0 cm ; the shell centers are separated by $L=10 \mathrm{~cm}$. In unitvector notation, what is the net electric field at $x=2.0 \mathrm{~cm}$ ?


## Problem 19

Space vehicles traveling through Earth's radiation belts can intercept a significant number of electrons. The resulting charge buildup can damage electronic components and disrupt operations. Suppose a spherical metal satellite 1.3 m in diameter accumulates $2.4 \mu \mathrm{C}$ of charge in one orbital revolution. (a) Find the resulting surface charge density. (b) Calculate the magnitude of the electric field just outside the surface of the satellite, due to the surface charge.

## Problem 26

Figure 23-37a shows a narrow charged solid cylinder that is coaxial with a larger charged cylindrical shell. Both are nonconducting and thin and have uniform surface charge densities on their outer surfaces. Figure $23-37$ b gives the radial component E of the electric field versus radial distance r from the common axis, and $\mathrm{E}_{\mathrm{s}}=3.0 \times 10^{3} \mathrm{~N} / \mathrm{C}$. What is the shell's linear charge density?
(a)



## Problem 31

Two long, charged, thin-walled, concentric cylindrical shells have radii of 3.0 and 6.0 cm . The charge per unit length is $5.0 \times 10^{-6} \mathrm{C} / \mathrm{m}$ on the inner shell and $-7.0 \times 10^{-6} \mathrm{C} / \mathrm{m}$ on the outer shell. What are the (a) magnitude $E$ and (b) direction (radially inward or outward) of the electric field at radial distance $r=4.0 \mathrm{~cm}$ ? What are (c) $E$ and (d) the direction at $r=8.0 \mathrm{~cm}$ ?

## Problem 39

In Fig. 23-45, a small, nonconducting ball of mass $m=1.0 \mathrm{mg}$ and charge $q=2.0 \times 10^{-8} \mathrm{C}$ (distributed uniformly through its volume) hangs from an insulating thread that makes an angle $\theta=30^{\circ}$ with a vertical, uniformly charged nonconducting sheet (shown in cross section). Considering the gravitational force on the ball and assuming the sheet extends far vertically and into and out of the page, calculate the surface charge density $\sigma$ of the sheet.


## Problem 41

An electron is shot directly toward the center of a large metal plate that has surface charge density $-2.0 \times 10^{-6} \mathrm{C} / \mathrm{m}^{2}$. If the initial kinetic energy of the electron is $1.60 \times 10^{-17} \mathrm{~J}$ and if the electron is to stop (due to electrostatic repulsion from the plate) just as it reaches the plate, how far from the plate must the launch point be?

## Problem 49

In Fig. 23-50, a solid sphere of radius $a=2.00 \mathrm{~cm}$ is concentric with a spherical conducting shell of inner radius $b=2.00 a$ and outer radius $c=2.40 a$. The sphere has a net uniform charge $q_{1}=+5.00 \mathrm{fC}$; the shell has a net charge $q_{2}=-q_{1}$. What is the magnitude of the electric field at radial distances (a) $r=0$, (b) $r=a / 2.00$, (c) $r=a$, (d) $r=1.50 a$, (e) $r=2.30 a$, and (f) $r=3.50 a$ ? What is the net charge on the (g) inner and (h) outer surface of the shell?


## Problem 76

Charge is distributed uniformly throughout the volume of an infinitely long solid cylinder of radius $R$. (a) Show that, at a distance $r<R$ from the cylinder axis,

$$
E=\frac{\rho r}{2 \varepsilon_{0}}
$$

where r is the volume charge density. (b) Write an expression for $E$ when $r>R$.

