## Homework for Chapter 24

(Due 9/29/22)

Questions: 4, 6, 10
Exercises \& Problems: 11, 19, 25, 33, 35, 53, 54, 67, 99

## Question 4

Figure 24-24 gives the electric potential $V$ as a function of $x$. (a) Rank the five regions according to the magnitude of the $x$ component of the electric field within them, greatest first. What is the direction of the field along the $x$ axis in (b) region 2 and (c) region 4?


## Question 6

Figure 24-26 shows four arrangements of charged particles, all the same distance from the origin. Rank the situations according to the net electric potential at the origin, most positive first. Take the potential to be zero at infinity.


## Question 10

(a) In Fig. 24-28a, what is the potential at point $P$ due to charge $Q$ at distance $R$ from $P$ ? Set $V=0$ at infinity. (b) In Fig. 24-28b, the same charge $Q$ has been spread uniformly over a circular arc of radius $R$ and central angle $40^{\circ}$. What is the potential at point $P$, the center of curvature of the arc? (c) In Fig. 24-28c, the same charge $Q$ has been spread uniformly over a circle of radius $R$. What is the potential at point $P$, the center of the circle? (d) Rank the three situations according to the magnitude of the electric field that is set up at $P$, greatest first.


## Problem 11

A nonconducting sphere has radius $R=2.31 \mathrm{~cm}$ and uniformly distributed charge $q=+3.50 \mathrm{fC}$. Take the electric potential at the sphere's center to be $V_{0}=0$. What is $V$ at radial distance (a) $r=$ 1.45 cm and (b) $r=R$. (Hint: See Section 23-9.)

## Problem 19

In Fig. 24-35, particles with the charges $q_{1}=+5 e$ and $q_{2}=-15 e$ are fixed in place with a separation of $d=24.0 \mathrm{~cm}$. With electric potential defined to be $\mathrm{V}=0$ at infinity, what are the finite (a) positive and (b) negative values of $x$ at which the net electric potential on the $x$ axis is zero?


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## Problem 25

A plastic rod has been bent into a circle of radius $R=8.20 \mathrm{~cm}$. It has a charge $Q_{1}=+4.20 \mathrm{pC}$ uniformly distributed along one-quarter of its circumference and a charge $Q_{2}=-6 Q_{1}$ uniformly distributed along the rest of the circumference (Fig. 24-39). With $V=0$ at infinity, what is the electric potential at (a) the center $C$ of the circle and (b) point $P$, on the central axis of the circle at distance $D=6.71 \mathrm{~cm}$ from the center?


## Problem 33

The thin plastic rod shown in Fig. 24-42 has length $L=12.0 \mathrm{~cm}$ and a nonuniform linear charge density $\lambda=c x$, where $c=28.9 \mathrm{pC} / \mathrm{m}^{2}$. With $\mathrm{V}=0$ at infinity, find the electric potential at point $\mathrm{P}_{1}$ on the axis, at distance $\mathrm{d}=3.00 \mathrm{~cm}$ from one end.


Problem 35
The electric potential at points in an $x y$ plane is given by $V=\left(2.0 \mathrm{~V} / \mathrm{m}^{2}\right) x^{2}-\left(3.0 \mathrm{~V} / \mathrm{m}^{2}\right) y^{2}$. In unitvector notation, what is the electric field at the point $(3.0 \mathrm{~m}, 2.0 \mathrm{~m})$ ?

Problem 53
Two tiny metal spheres $A$ and $B$, mass $m_{A}=5.00 \mathrm{~g}$ and $m_{B}=10.0 \mathrm{~g}$, have equal positive charge $q=5.00 \mu \mathrm{C}$. The spheres are connected by a massless nonconducting string of length $d=1.00 \mathrm{~m}$, which is much greater than the radii of the spheres. (a) What is the electric potential energy of the system? (b) Suppose you cut the string. At that instant, what is the acceleration of each sphere? (c) A long time after you cut the string, what is the speed of each sphere?

## Problem 54

A positron (charge $+e$, mass equal to the electron mass) is moving at $1.0 \times 10^{7} \mathrm{~m} / \mathrm{s}$ in the positive direction of an $x$ axis when, at $x=0$, it encounters an electric field directed along the $x$ axis. The electric potential $V$ associated with the field is given in Fig. 24-52. The scale of the vertical axis is set by $V_{s}=500.0 \mathrm{~V}$. (a) Does the positron emerge from the field at $x=0$ (which means its motion is reversed) or at $x=0.50 \mathrm{~m}$ (which means its motion is not reversed)? (b) What is its speed when it emerges?


## Problem 67

A metal sphere of radius 15 cm has a net charge of $3.0 \times 10^{-8} \mathrm{C}$. (a) What is the electric field at the sphere's surface? (b) If $V=0$ at infinity, what is the electric potential at the sphere's surface? (c) At what distance from the sphere's surface has the electric potential decreased by 500 V ?

## Problem 99

(a) Using Eq. 24-32, show that the electric potential at a point on the central axis of a thin ring (of charge $q$ and radius $R$ ) and at distance $z$ from the ring is

$$
V=\frac{1}{4 \pi \varepsilon_{0}} \frac{q}{\sqrt{z^{2}+R^{2}}}
$$

(b) From this result, derive an expression for the electric field magnitude $E$ at points on the ring's axis; compare your result with the calculation of $E$ in Section 22-6.

