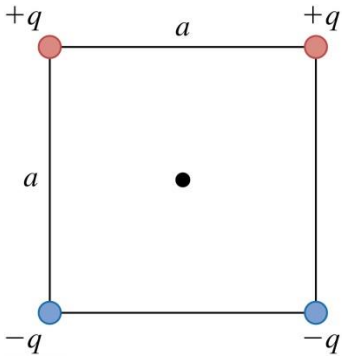
PC1432 PHYSICS IIE

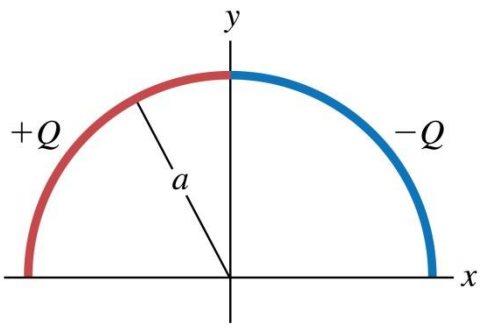
Tutorial Exercise 1

1. [Y&F 21.30] A point charge is placed at each corner of a square with side length a. The charges all have the same magnitude q. Two of the charges are positive and two are negative, as shown in the figure. What is the direction of the net electric field at the centre of the square due to the four charges, and what is its magnitude in terms of q and a? [Answer: $\left|\vec{E}\right| = \frac{\sqrt{2}q}{\pi\epsilon_0 a^2}$, downwards]



2. [Y&F 21.98] A semicircle of radius a is in the first and second quadrants, with the centre of curvature at the origin. Positive charge $+Q$ is distributed uniformly around the left half of the semicircle, and negative charge $-Q$ is distributed around the right half of the semicircle (see figure). What are the magnitude and direction of the net electric field at the origin produced by this distribution of charge?

[Answer: $\left|\vec{E}\right| = \frac{Q}{\pi^2\epsilon_0 a^2}$, along positive x-direction]

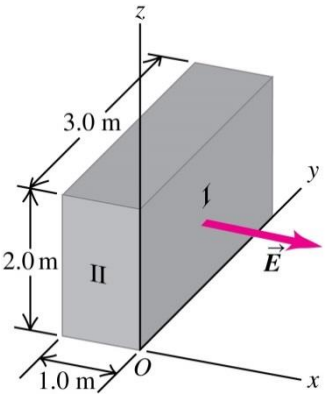


3. [Y&F 22.35] The electric field $\vec{\boldsymbol{E}}$ in the figure is everywhere parallel to the x-axis, so the components E_y and E_z are zero. The x-component of the field E_x depends on x but not on y and z. At points in the yz-plane (where $x = 0$), $E_x = 125\ \mathrm{N/C}$.

(a) What is the electric flux through surface I in the figure?

[Answer: 750 $\mathrm{Nm^2/C}$]

(b) What is the electric flux through surface II?

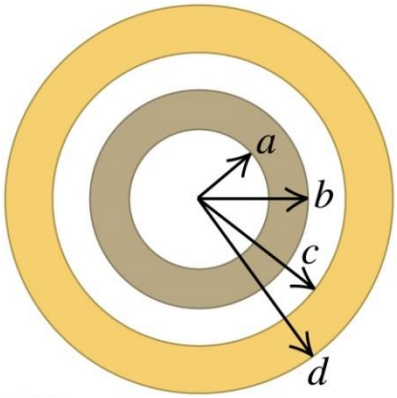


(c) The volume shown in the figure is a small section of a very large insulating slab 1.0 m thick. If there is a total charge -24.0 nC within the volume shown in the figure, what are the magnitude and direction of $\vec{\boldsymbol{E}}$ at the face opposite surface I?

[Answer: $\vec{\boldsymbol{E}} = 577\ \mathrm{N/C}\ \hat{\imath}$]

(d) Is the electric field produced only by charges within the slab, or is the field also due to charges outside the slab? How can you tell?

4. [Y&F 22.47] A small conducting spherical shell with inner radius a and outer radius b is concentric with a larger conducting spherical shell with inner radius c and outer radius d. The inner shell has total charge $+2q$, and the outer shell has charge $+4q$.



(a) Calculate the electric field (magnitude and direction) in terms of q and the distance r from the common centre of the two shells for (i) $r < a$; (ii) $a < r < b$; (iii) $b < r < c$; (iv) $c < r < d$; (v) $r > d$. Show your results in a graph of the radial component of $\vec{\boldsymbol{E}}$ as a function of r.

[Answer: (i) $E = 0$; (ii) $E = 0$; (iii) $E = \frac{2q}{4\pi\epsilon_0 r^2}$; (iv) $E = 0$; (v) $E = \frac{6q}{4\pi\epsilon_0 r^2}$]

(b) What is the total charge on the (i) inner surface of the small shell; (ii) outer surface of the small shell; (iii) inner surface of the large shell; (iv) outer surface of the large shell?