23.4-23.5

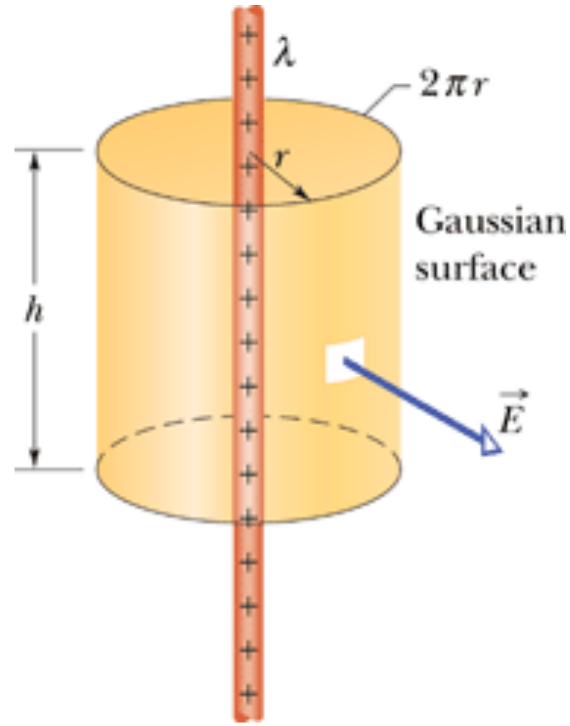
#9: Cylindrical and Planar

Imagine charge distributed evenly on a long, straight wire.

Cylindrical symmetry

Electric field must point radially out/in

Consider a cylindrical Gaussian surface.



$$\oint \vec{E} \bullet d\vec{A} = \int_{ends} \vec{E} \bullet d\vec{A} + \int_{side} \vec{E} \bullet d\vec{A}$$

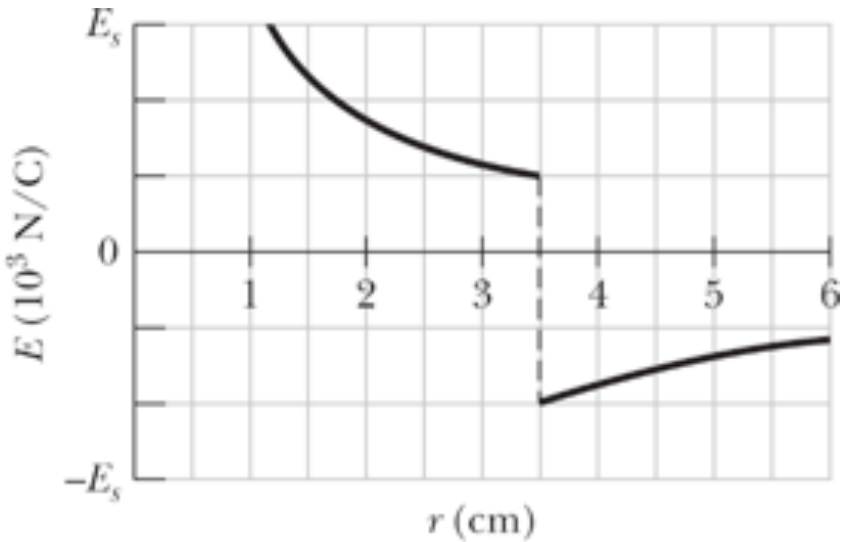
For the ends of the cylinder $\vec{E} \bullet d\vec{A} = 0$

For the side of the cylinder $\vec{E} \bullet d\vec{A} = EdA$

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

$$\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = \varepsilon_0 E \int dA = \varepsilon_0 E(2\pi rh) = q_{enc} = \lambda h$$

A coaxial cable can be accurately modelled as a long thin wire surrounded by an insulating material, which is then surrounded by a thin conducting shell. The plot shows the electric field as the function of distance from the center of such a coaxial cable. If the linear charge density on the cental conductor is λ, what is the linear charge density on the external conductor?



A. ***0***

B. ***-λ***

C. ***-2λ***

D. ***-3λ***

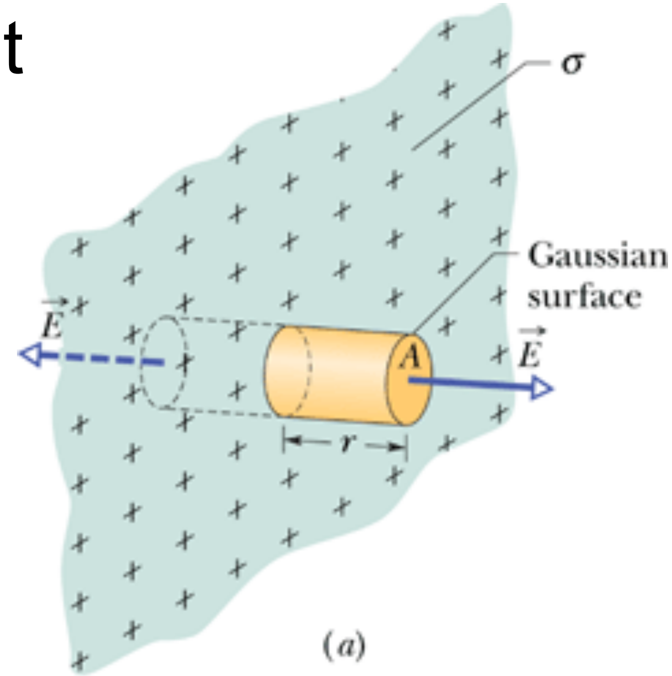
E. ***-4λ***

Insulating sheet

Consider a uniform distribution of charges in a large, flat ***insulating sheet***

Consider a cylindrical Gaussian surface

$$\oint \vec{E} \bullet d\vec{A} = \int_{end-1} \vec{E} \bullet d\vec{A} + \int_{end-2} \vec{E} \bullet d\vec{A} + \int_{side} \vec{E} \bullet d\vec{A}$$

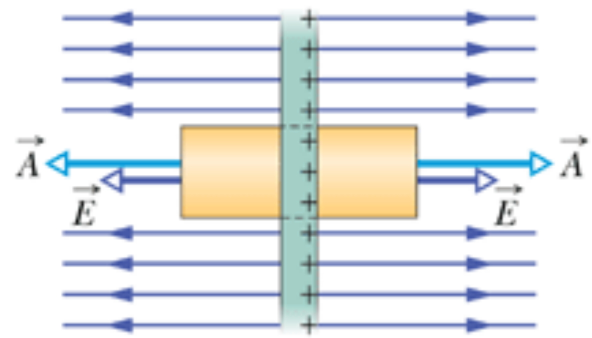


(a)

Planar symmetry → electric field must point perpendicular to the sheet

For the sides of the cylinder $\vec{E} \bullet d\vec{A} = 0$

For the ends of the cylinder $\vec{E} \bullet d\vec{A} = EdA$



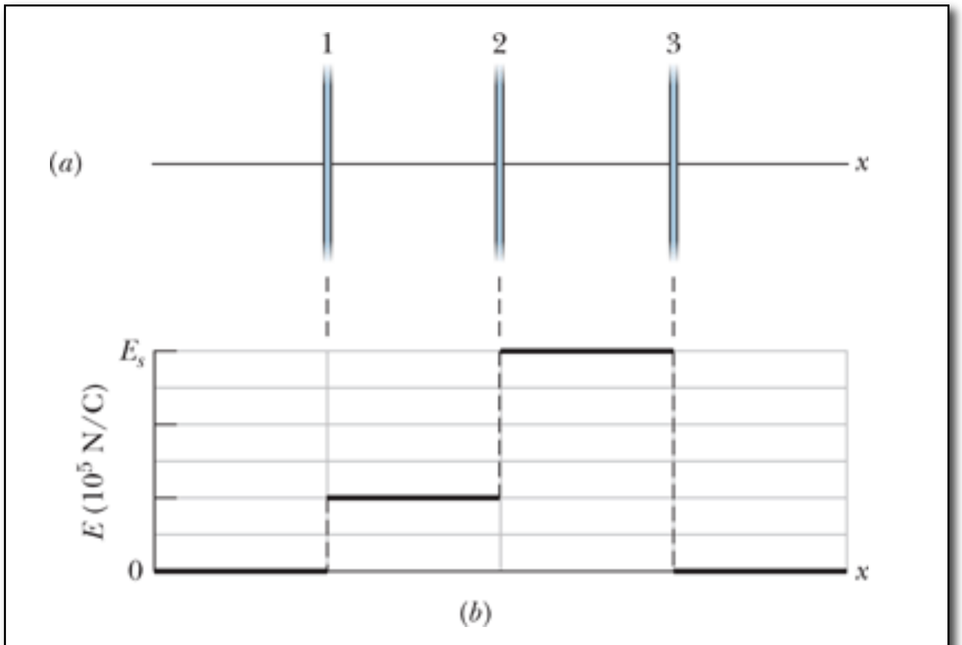
(b)

$$\oint \vec{E} \bullet d\vec{A} = E \int_{end-1} dA + E \int_{end-2} dA$$

$$\varepsilon_0 \oint \vec{E} \bullet d\vec{A} = 2EA = q_{enc} = \sigma A$$

$$E = \frac{\sigma}{2\varepsilon_0}$$

The figure below shows three plastic sheets that are large, parallel, and uniformly charged. The components of the net electric field along an x axis through the sheets are also plotted. (a) What is σ_1? (b) What is $\sigma_1 + \sigma_2 + \sigma_3$



A. 0

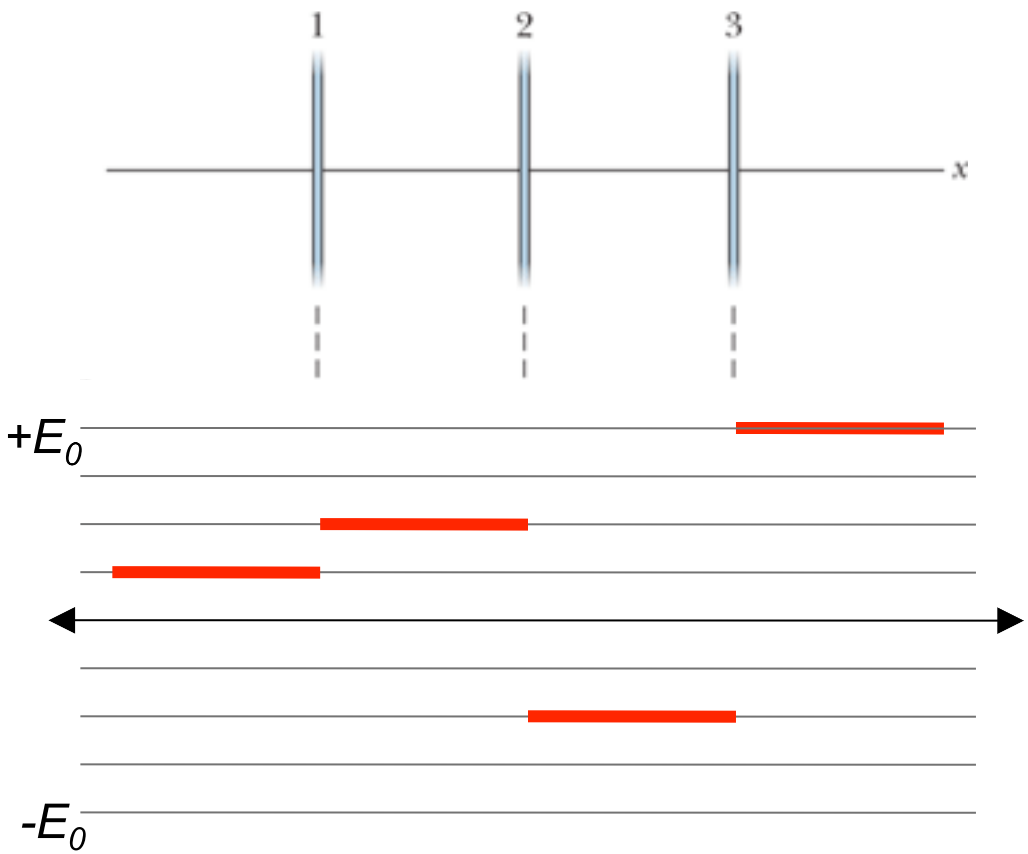
B. $\varepsilon_0 E_s / 2$

C. $\varepsilon_0 E_s / 3$

D. $\varepsilon_0 E_s / 6$

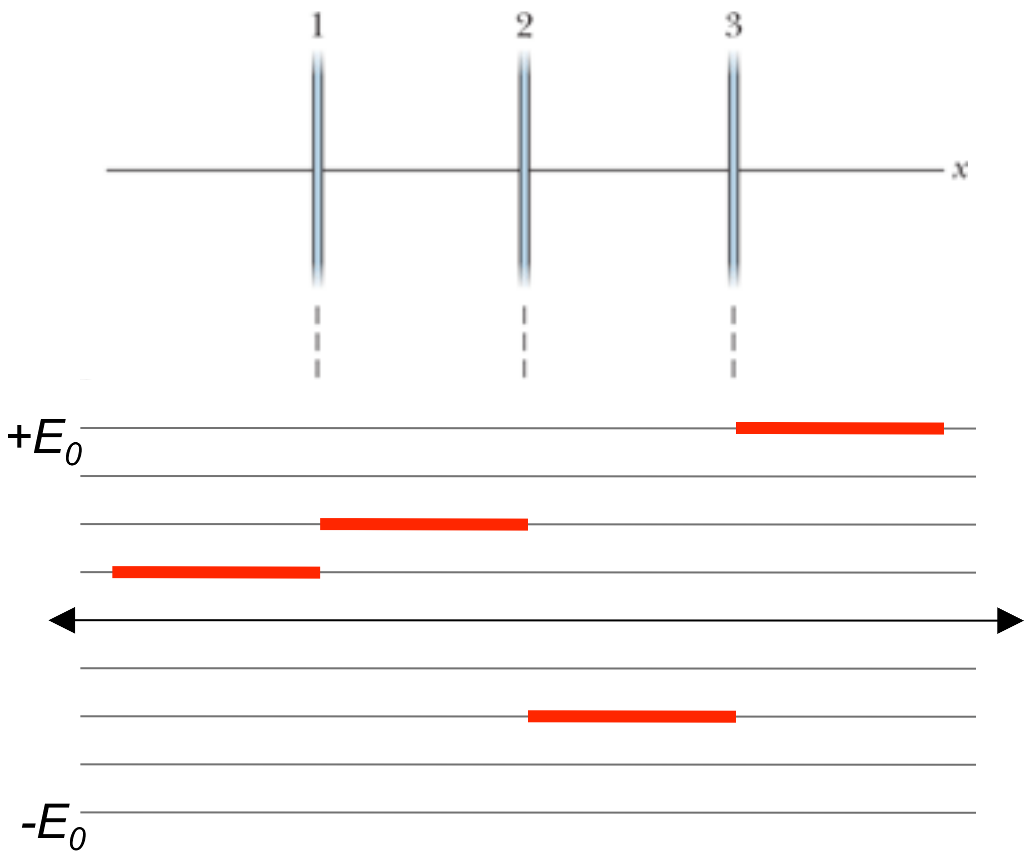
E. $-\sigma_2$

Three thin non conducting sheets are shown below.
What is charge density on sheet 1?



A. 0
B. $\varepsilon_0 E_0 / 4$
C. $\varepsilon_0 E_0 / 2$
D. $3\varepsilon_0 E_0/4$
E. $\varepsilon_0 E_0$

Three thin non conducting sheets are shown below.
What is charge density on sheet 2?



A. 0

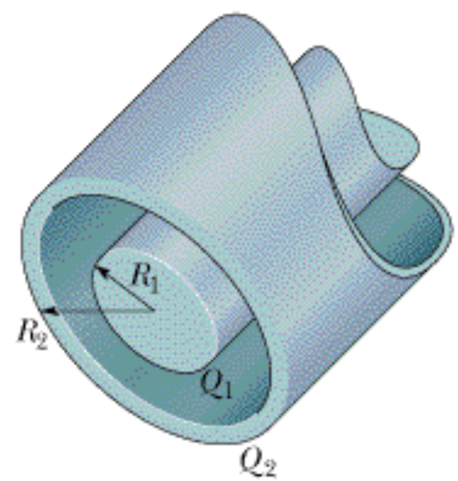
B. $\varepsilon_0 E_0 / 2$

C. $-\varepsilon_0 E_0 / 2$

D. $\varepsilon_0 E_0$

E. $-\varepsilon_0 E_0$

The figure below is a section of a conducting rod of radius $R_1 = 1.00\ mm$ and length $L = 10.0\ m$ inside a thick-walled coaxial conducting cylindrical shell of radius $R_2 = 10.0R_1$ and the (same) length L. The net charge on the rod is $Q_1 = +3.4\ pC$ that on the shell is $Q_2 = -2.0Q_1$. What is the magnitude and direction of the electric field at $r = 2.0R_2$ and $r = 5.0\ R_1$?



Two very long, thin, plastic rods lie in the z direction at (x=-a,y=0) and (x=+a,y=0). The rods carry a uniform charge density λ. Find an expression net electric field for points that lie on the y axis. At what point on the y axis is the magnitude of the electric field a maximum?