1. (23-56) Field lines leave a closed box, but every line that leaves the box must enter: 
   a) False – there must be charge in the box or else no field lines would emerge. 
   b) False – there would have to be a net flux out of the box if it held a net positive charge. 
   c) False – there would have to be a net flux into the box if it held a net negative charge. 
   d) True

2. (23-57) By Gauss’s law \( \Phi_E = \frac{Q_{in}}{\varepsilon_0} \)
   
   \[ \Phi_E = \frac{6.5 \times 10^{-8} \text{ C}}{8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2} = 7300 \frac{\text{N}\cdot\text{m}^2}{\text{C}} \]

   To find the flux through each face, we would need to know the location of the charge. If the charge were at the center, the flux would be the same through each face.
   
   \[ \Phi_{\text{face}} = \frac{\Phi_E}{4} = 1800 \frac{\text{N}\cdot\text{m}^2}{\text{C}} \]
To find the field \( \vec{E} \) at \( P \) we use Gauss's Law with a Gaussian surface consisting of a sphere of radius 21 cm, as shown.

Then, since \( \vec{E} = E \hat{r} \) and \( \hat{n} = \hat{r} \)
we have \( \vec{E} \cdot \hat{n} = E \) and

\[
\Phi_E = \int \vec{E} \cdot \hat{n} \, dA = E \int dA = 4\pi r^2 E = \frac{Q_{\text{in}}}{\varepsilon_0}
\]

Thus

\[
E = \frac{Q_{\text{in}}}{4\pi r^2} = \frac{16 \times 10^{-9} \text{C}}{4\pi \left(8.85 \times 10^{-12} \text{C}^2/\text{N}\cdot\text{m}^2\right)(0.21 \text{m})}
\]

\[
E = 3300 \frac{\text{N}}{\text{C}}
\]

So \( \vec{E} = 3300 \frac{\text{N}}{\text{C}} \hat{r} \) (Note typo error in text answer.

Apply Gauss's Law with a Gaussian surface consisting of a box of height \( 2h \) and top and bottom area each = \( A \).

Then \( \Phi_E = EA + EA = \frac{Q_{\text{in}}}{\varepsilon_0} \)

So \( 2EA = \frac{Q_{\text{in}}}{\varepsilon_0} \)

\[
E = \frac{(4.6 \times 10^{-3} \varepsilon_0 \text{m}^{-2}) A}{2 \left(8.85 \times 10^{-12} \text{C}^2/\text{N}\cdot\text{m}^2\right)} \approx 2.6 \times 10^8 \frac{\text{N}}{\text{C}}
\]
5. (24-12) Gauss's Law for points near the center of the force. For points near edges we do not have enough symmetry to make Gauss's Law useful.

Apply Gauss's Law with a spherical Gaussian surface of radius \( r > R \), and \( r < R \). The field must be radial by symmetry. \( \Phi_E = \Phi \), so

\[
\Phi_E = \int \vec{E} \cdot \hat{r} \, dA = E \int dA = \frac{Q}{\varepsilon_0}
\]

Thus \( 4\pi r^2 E = \frac{Q}{\varepsilon_0} \)

\[
\vec{E} = \frac{Q}{4\pi \varepsilon_0 r^2} \hat{r} = \frac{\vec{E}_0 \hat{r}}{r^2}
\]

7. (24-20) Apply Gauss's Law with cylindrical Gaussian surface of radius \( r = 0.67 \) mm and length \( l \).

\[
\Phi_E = 2\pi rl E = \frac{Q}{\varepsilon_0}
\]

Thus \( \vec{E} = \frac{\lambda}{2\pi \varepsilon_0 r} \hat{r} = \frac{2.7 \times 10^{-9} \text{ C/m}^2 \hat{r}}{2\pi (8.85 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2) (6.7 \times 10^{-9} \text{ m})} \)
24-20: Thus \[ \vec{E} = -7.2 \times 10^4 \frac{N}{C} \hat{r} \]

8, (24-22)

\[ 4\pi = 1.2 \text{ cm}^2 \]

As in previous problem

\[ E = \frac{\lambda}{2\pi \varepsilon_0 r} \]

Thus \[ \lambda = 2\pi \varepsilon_0 r E \]

\[ = 2\pi \left( 8.85 \times 10^{-12} \frac{C^2}{N\text{m}^2} \right) \left( \frac{1.2 \times 10^{-2}}{1.5 \times 10^{-4}} \right) \]

\[ \lambda = 1.0 \times 10^{-8} \frac{C}{m} \]

The filament has length \( l = 15 \text{ cm} \), so its charge is

\[ Q = \lambda l = \left( 1.0 \times 10^{-8} \frac{C}{m} \right) (1.5 \times 10^{-1} \text{ m}) \]

\[ = +1.5 \times 10^{-9} C \]

(The filament must have positive charge since electrons are attracted towards it.)