Problem Set Solutions - 5

25.5

(a) Only the E-field is zero at center of triangle. The electric potential at P is 3 \( kQ \). Since all the charges have the same sign, the potential is only zero at \( \infty \). The E-fields are \( 3 \) vectors of equal magnitude that sum to zero.

25.45

Use conservation of energy

<table>
<thead>
<tr>
<th>Potential</th>
<th>Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 2kQq/e )</td>
<td>( kQq/e )</td>
<td></td>
</tr>
</tbody>
</table>

25.7

\[ 2kQq/e + kQq/e = kQq/e + K \]

\[ \Rightarrow K = \frac{2kQq}{e} \]

25.80

Point A: The distance between equipotential surfaces is approximately \( \frac{1}{2} \) m; \( \Delta V = 10^{-3} \) V. Using \( \Delta V = Ed \), the E-field at A is \( E_A = \Delta V / d = 10^{-3} V/m = 2 \times 10^{-2} V/m \)

Point B: \( d = 2/6 \) m, \( \Delta V = 10^{-3} \) V so \( E = 10^{-3} V/m \) m = \( 1.5 \times 10^{-2} V/m \)

The direction of \( E \) is toward lower potential, or toward the origin in both cases, perpendicular to the equipotential surfaces.
Model this as a collection of infinitesimal elements, each with charge \( dq = \lambda \, dx \) and potential at \( P \) of \( dV = \frac{k \lambda dx}{\sqrt{x^2 + y^2}} \). Since the LHS is symmetric to the RHS, integrate \( dV \) from 0 to \( L/2 \) and multiply by 2.

\[
V = 2 \int_0^{L/2} \frac{k \lambda dx}{\sqrt{x^2 + y^2}}
\]

However, since \( L \) is significantly less than \( y \), I can approximate the filament as a point charge with net charge \( Q = \lambda L \). Then, the potential a distance \( y \) away is:

\[
V = \frac{kQ}{y} = \frac{k \lambda L}{y} = \frac{(9 \times 10^9 \text{ Nm}^2/\text{C}^2)(6.7 \times 10^{-6} \text{ C/m})(3 \times 10^{-2} \text{ m})}{1.8 \text{ m}}
\]

\[
= 1.0 \times 10^3 \text{ V}
\]
The E-field between the plates is $\vec{E} = \frac{\sigma}{\varepsilon_0}$ to the right, from hw prob 24.40 b.

$$\Delta V = V_A - V_B = -\int_B^A \vec{E} \cdot d\vec{l} = \int_B^A \frac{\sigma}{\varepsilon_0} \cdot (-dx \hat{\imath}) = \frac{\sigma}{\varepsilon_0} \int_B^A dx = \frac{\sigma}{\varepsilon_0} (\frac{1}{2}) = 2\pi k \sigma \ell$$

(k = $\frac{1}{4\pi \varepsilon_0}$)

25.41 red side is positive, blue is negative. So the E-field at A points away from red, toward A, and perpendicular to the surface. Thus (d) is the best choice.
(a) is normal to the object but in the wrong direction
(b) not even close
(c) the result if the object were not present

25.70 Since charge is conserved, the net charge in the final state must equal the net charge initially. Initially, both spheres were uncharged, so $Q_{\text{net}, i} = 0$. Thus, $Q_{\text{net}, f} = 0$. The only viable option is (e)
If the spheres are now moved a great distance apart, the potential on each is due to its own charge
$$V_A = \frac{kQ_A}{r_A}, \quad V_B = \frac{kQ_B}{r_B} = -\frac{kQ_A}{r_B}$$
Since $V_A$ is + and $V_B$ is -, $V_A > V_B$. Since $r_A < r_B$
$|V_A| > |V_B|$