18-2Q
There are two ways to think about this question- one is to simple work with the potential. We know that positive charges move to lower potentials and negative charges move to higher potentials (both charges are simply trying to lower their potential energy). (see example 4). So, a proton would move to the left from P, and an electron would move down from R. The second way to think about this (and possibly to use it as a check), is to remember that potential is lower near negative charges. This means that at the center of our figure, there is a negative charge. Now we simply use the fact that opposite charges attract, and like repel. Again, a proton would move to the left (toward the negative charge) and an electron would move down (away from the negative charge).

18-4Q
Here we are given Equipotential lines, in other words at all points on the outermost dashed line the potential is 4V. In general, when you move along an equipotential line, you are keeping your potential, and therefore potential energy constant. This means that the field does no work. The only way for this to happen is if the field lines are perpendicular to the equipotential lines. This gives us a sense of what the electric field looks like. Also, in example 7, we are reminded of the relationship between potential and field. For approximately uniform fields (which is true if we are looking at a small enough region of space), \( V = Ed \).

a) We know that the electric field lines point from high to low potential, and are perpendicular to the equipotential surfaces. This means that at point D, the field is pointing to the right.

b) The field will be the greatest where there is a rapid change in potential (where the equipotential lines are closely spaced). This means that at A the field has a greatest magnitude.

18-2P
This is essentially a conservation of energy problem. We’re converting electrical potential energy into kinetic energy. Initially, the proton is at rest, so the kinetic energy is zero at the start.

\[
\begin{align*}
E_i &= E_f \\
E_i &= K_i + U_i = 0 + U_i \\
E_f &= K_f + U_f \\
K_f &= U_i - U_f
\end{align*}
\]

The final kinetic energy is simply the – change in the potential energy.
To get the change, we can relate the potential energy to the potential.

\[ K_f = U_i - U_f \]

\[ K_f = q(V_i - V_f) \]

Using \(1.6 \times 10^{-19}\) C for the charge of the proton and the given potentials, we find that the final kinetic energy is \(4.8 \times 10^{-17}\) J. While this sounds like a small amount of energy, remember that the proton has a small mass, so it would be moving quite fast.

18-6P

While the configuration is the same as 17-17P, this question is actually easier to answer as we are working with a scalar, rather than a vector. To get the total potential at P we simply add the potential due to each charge.

For a point charge:

\[ V = \frac{kq}{r} \]

so, the potential due to each charge, at P, is 1V. Making the total potential 2V. Notice we never are concerned with the 40°, as potential is a scalar.

18-16P

This is very similar to 18-2P, in that we’re changing electric potential energy into kinetic energy for a proton. Since we want the potential change, we will actually use the kinetic energy to find this. Again, the particle is starting from rest, making the initial kinetic energy zero.

\[ E_i = E_f \]
\[ E_i = K_i + U_i = 0 + U_i \]
\[ E_f = K_f + U_f \]
\[ K_f = U_i - U_f \]

What is the final kinetic energy? \(K_f= \frac{1}{2} m v^2\), but what is the final speed? We are given the time it takes to travel 5cm, from this we can find the final speed.

\[ \text{speed} = \frac{\text{distance}}{\text{time}} = \frac{0.05m}{10^{-3}s} = 5 \times 10^4 m/s \]

Right? No! This isn’t what we want. This is the average speed, not final speed. To get the final speed we have to go one step further.

\[ 5 \times 10^4 m/s = \frac{1}{2}(v_f + v_i) = \frac{v_f}{2} \]
This means that the final speed is $10^5$ m/s. From this we can find that the kinetic energy is $8.35 \times 10^{-18}$ J. And, just as in the previous problem, we can relate the potential difference to the change in potential energy (which here is equal to the change in kinetic energy). For a proton (with $q = 1.6 \times 10^{-19}$ C), the change in potential is then $52V$.

18-20P
Here we are told to use the parallel plate geometry/approximation. For this situation we can relate the distance, area and capacitance via equation 18-14.

$$C = \frac{\epsilon A}{d} \quad d = \frac{\epsilon A}{C}$$

Using the given values of capacitance and area (0.1m x 0.2m), we find that the plates must be $1.77\text{mm}$ apart. To determine the electric field, and charge on each plate, given the 100V difference, we can proceed several different ways. First, let’s find the electric field. To do this we’re going to assume that the electric field is uniform between the plates. (This assumption is actually already built into the parallel-plate model.) So,

$$\Delta V = E d \quad E = \frac{\Delta V}{d}$$

So, the electric field is $57,000 \text{V/m}$.

The charge on each plate (one is $+Q$ and one is $-Q$) can be found using the definition of capacitance.

$$Q = CV$$

So, the charge is $\pm 10^{-8}\text{C}$ on the two plates.