The quantity described on the previous page is known as the change in 
electrostatic potential (or simply change in potential), it’s mathematical definition is:

\[ \Delta V = -\frac{W}{q} \]

Since the electric force is a conservative one we can relate the work done by the 
field to the potential energy stored in the system

\[ W = -\Delta U \]

so,

\[ \Delta V = \frac{\Delta U}{q} \]

Notice that the potential does not depend on the charge of the test particle, rather 
it only depends on the electric field. This is similar to what we saw with the electric 
force and electric field (the force depends on both the test particle and the environment whereas the field only depends on the environment). Also, you should notice that the potential is a collection of scalars, not a vectors. (For each point in space we will be able to define a scalar potential, much like what we did with creating the electric field out of a collection of vectors.)

Because the potential at any point in an electric field is a scalar, we can use it to 
describe electrostatic phenomena more simply than if we were to rely only on the 
concepts of the electric field and electric forces. Later we will be able to apply the idea of potential to circuits. Notice that the SI units of potential are volts; yes, these are the same volts we speak of when talking about currents.

As you begin reading chapter 25, try to think about the concepts behind the 
equations. There are lots of equations thrown at you in the first section. Nearly all of 
them follow from the simple ideas in this worksheet:

- The electric force is a conservative force. Therefore, we can relate the potential 
  energy of an electrostatic system to the work done by the field.
- We can define a new quantity known as the potential which only depends on the 
  electric field and not the test particle.
- The potential is a scalar (which will then be much simpler to work with then electric 
  fields).
14. Now instead of the \( +q \) charge, let’s move a \( +1.7q \) point charge from point C to D. How does the work done by the electric field on the particle in this second case compare to the work done in the original case with a \( +q \) charge? Is the work done by the field greater, less or the same? Explain.

a) How is the quantity \( \frac{\text{work done by the field}}{\text{charge of the particle}} \) affected by this change in charge?

b) Does this quantity depend on the magnitude of the charge that is used to measure it? Explain.

c) Does this quantity depend on the sign of the charge that is used to measure it? Explain.
11. Compare the work done by the electric field when the particle travels from point C to D to that done when the particle travels from point C to A along the path shown.

12. Suppose the particle travels from point C to point B via points D and A as shown in the next sketch. Compare the work done by the electric field when the particle travels from point C to D to that done when the particle travels from A to B. Explain.

What is the total work done on the particle by the electric field as it moves along the path CDAB?

13. Suppose the particle travels from C to B along the arc shown. Is the work done on the particle by the electric field positive, negative or zero? Explain.
7. The diagram shows a top view of a positively charged rod. Points A, B, C, and D lie in a plane near the center of the rod. Points B and C are equidistant from the rod, as are points A and D.

![Diagram of points A, B, C, and D]

Draw electric field vectors at points A, B, C, and D.

8. A particle with a positive charge $+q$ travels along a straight line from point C to D. Is the work done by the electric field (on the charged particle) positive, negative, or zero? Explain using a sketch that shows the electric force on the particle and the displacement of the particle.

9. Compare the work done by the electric field when the particle travels from point C to D to that done when the particle travels from point D to C.

10. The particle now travels from D to A along the circular arc shown. Is the work done by the electric field on the particle positive, negative, or zero? Explain. (Again try drawing the force vector that is acting on the particle as well as the displacement vector for several short intervals of the trip.)
Before starting the material in chapter 25, you should review chapter 7 - work and energy. Many of those ideas which relate forces and energy will come into play again as we study electric fields and potential energies. The exercises that follow are meant to help you recall some of the ideas from mechanics and learn how to apply them to electrostatic systems.

4. Suppose an object moves under the influence of a force. Sketch arrows showing the relative directions of the force and displacement vectors when the work done on the object is:

<table>
<thead>
<tr>
<th>Positive</th>
<th>Negative</th>
<th>Zero</th>
</tr>
</thead>
</table>

5. Consider an object that travels from point A to point B while two constant forces $F_1$ and $F_2$ are exerted on the object. Note that the forces have unequal magnitude and $F_1$ is directed toward point A and $F_2$ toward point B.

a) Is the total work done on the object by $F_1$ positive, negative or zero?

b) Is the total work done on the object by $F_2$ positive, negative or zero?

c) Is the net work done on the object positive, negative or zero?

6. Is the speed of the object at point B greater than, less than or equal to the speed of the object at point A? Explain. (Does this answer match your answer for the sign of the net work done on the particle?)
Before starting the material on potentials, let’s look at some applications of Gauss’ Law.

1. (24-10P) The electric flux through a cubical box 8.0cm on a side is $1.2 \times 10^3$ N·m/C². What is the total charge enclosed by the box?

2. (24-17P) A very long, thin wire has a uniform linear charge density of 50 µC/m. What is the electric field at a distance 2.0cm from the wire?

3. (24-19P) A charge of −30µC is distributed uniformly throughout a spherical volume of radius 10cm. Determine the electric field due to this charge at a distance of a) 2.0cm and c) 20.0 from the center of the sphere. (Yes, we’re skipping part b.)