Average: 86%
StDev: 23%

1. The moving proton, Q, will stop 1m away from the fixed proton, at which point the proton will have 0 kinetic energy. This tells us that the initial kinetic energy will be completely stored in the electric field, or in other words, the work done on the proton by the electric field will be equal to the initial kinetic energy.

$$K_f + W = K_0 = W$$

$$K_0 = \frac{1}{2}mv^2$$

$$dW = F * dx = qE * dx$$

$$= \frac{-1}{4\pi\varepsilon_0}\frac{q^2}{x^2}dx$$

$$W = \frac{-q^2}{4\pi\varepsilon_0}\int_{\infty}^{1m}\frac{1}{r^2}dr = +\frac{q^2}{4\pi\varepsilon_0}\left[\frac{1}{r}\right]_{\infty}^{1m}$$

$$+\frac{q^2}{4\pi\varepsilon_0}\left[\frac{1}{1m}-\frac{1}{\infty}\right] = +\frac{q^2}{4\pi\varepsilon_0}\frac{1}{m}$$

$$K_0 = \frac{1}{2}m_p v^2 = \frac{q^2}{4\pi\varepsilon_0}\frac{1}{m}$$

$$v = \sqrt{\frac{2q^2}{4\pi\varepsilon_0 m_p}\frac{1}{m}} = 0.526\frac{m}{s}$$

Some of you did this in a much simpler way, using equation 25.11 for the electric potential energy and saying kinetic energy (before) = potential energy (after). If you did this you will, of course, not lose any points *unless* you copied equation 25.11 down wrong (some students had r in their denominator instead of r^2 – they will lose 1 pt.)

2. This is straight forward.

$$F = k = Nmm/CC$$

$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} = 8.99*10^9\frac{Nm^2}{C^2}\frac{1.6*10^{-19}C}{1m^2}$$

$$= 1.44*10^{-9}\frac{N}{C}$$

And because the charges are alike the field away from the source, aka to the left.

3.
In the first problem, we started with all kinetic energy and no potential energy and ended with all potential energy and no kinetic energy. Now, we are going in reverse. Since we assume energy conservation and the mass of every proton is the same, we can

immediately see that the final speed of P will be equal to the initial velocity of Q, so 0.526 m/s, but in this case in the opposite direction.

If you got the #1 wrong but recognized that the answer to 3 should be the same as the answer to 1, I gave you 1.5 pts since that was the physics of this problem.