Quiz 3: Solution

1. If you place a positively charged particle in an electric field, the charge will move

- □ from higher to lower electric potential and from lower to higher potential energy.
- ■ from higher to lower electric potential and from higher to lower potential energy.
- □ from lower to higher electric potential and from lower to higher potential energy.
- □ from lower to higher electric potential and from higher to lower potential energy.

2. You have five capacitors, each with a rated value of $C = 1 \times 10^{-6}$ F. What is the equivalent capacitance when they are all combined in parallel? In series?

Capacitors add in parallel, so five identical 1×10^{-6} F capacitors connected in parallel will give a capacitance 5 times higher, or 5×10^{-6} F.

Capacitors add inversely in series. Two identical capacitors in series give an equivalent capacitance half as much as a single capacitor, three identical capacitors in series give one third the original capacitance, and so on. Five 1×10^{-6} F capacitors in series will give one fifth of 1×10^{-6} F, or 2×10^{-7} F.

3. Calculate the speed of a proton that is accelerated from rest through a potential difference of 130 V.

- □ 3.21×10^4 m/s
- □ 7.9×10^4 m/s
- □ 6.76×10^6 m/s
- ■ 1.58×10^5 m/s

If the proton is accelerated from rest, its change in potential energy is equal to the opposite of its change in kinetic energy. The change in potential energy is the potential difference ΔV the proton moves through times its charge e. Thus,

$$\frac{1}{2}mv^2 = e\Delta V$$

$$v = \sqrt{\frac{2e\Delta V}{m}} \approx 1.58 \times 10^5 \text{ m/s}$$

4. Suppose that near the ground directly below a thundercloud, the electric field is of a constant magnitude of 2.0×10^4 V/m and points upward. What is the potential difference between the ground and a point in the air, 50 m above ground?

Potential energy is potential energy per unit charge; change in potential energy is the negative of the work done, which is the electric field times the charge moved times the displacement.

$$\Delta V = \frac{\Delta PE}{q} = \frac{-W}{q} = \frac{qE\Delta x}{q} = E\Delta x \approx 10^6\,\mathrm{V} \tag{1}$$