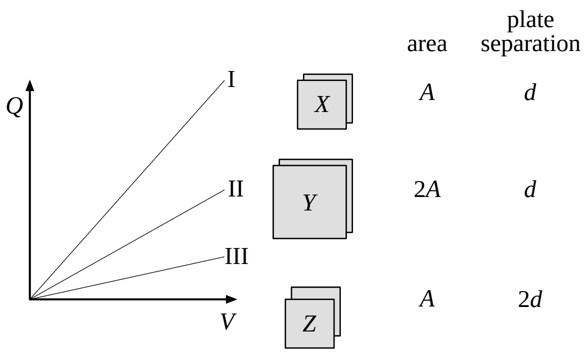
Physical Constants:
proton charge = $e = 1.60 \times 10^{-19}$ C
permittivity = $\varepsilon_0 = 8.85 \times 10^{-12}\ \mathrm{C^2/(N \cdot m^2)}$
Coulomb constant = $k = 9 \times 10^9\ \mathrm{N \cdot m^2/C^2}$

Select the letter of the single best answer. Each answer is worth 1 point.

1. A 6 μF and a 3 μF capacitor are connected in series and the combination is connected across a 9 V battery.

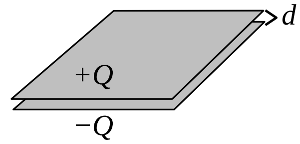
   A. The voltage drop across the 6 μF capacitor is half the voltage drop across the 3 μF capacitor.
   B. The charge stored on the 6 μF capacitor is equal to the charge stored on the 3 μF capacitor.
   C. Together the two capacitors act like one 2 μF capacitor.
   D. All of the above are true.

2. The geometry of three different air-filled parallel plate capacitors (called X, Y, Z) is displayed below along with plots (for each capacitor) of the charge stored on a capacitor plate (Q) vs. the potential difference between the plates (V). Which capacitor goes with which curve?



   A. Curve I is capacitor X
   B. Curve II is capacitor Y
   C. Curve III is capacitor Z
   D. all of the above

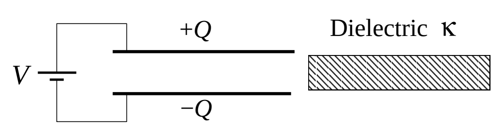
3. A capacitor, with parallel plates separated by a tiny distance d, carries charge ($\pm Q$) and is isolated (i.e., disconnected from any battery). If d is increased slightly which of the following best describes the changes that might be measured:



   I. the charge on the plates increases
   II. the voltage across the the plates increases
   III. the energy stored by the capacitor increases
   IV. the electric field in the middle of the capacitor decreases

   A. II, III
   B. II, IV
   C. II, III, IV
   D. I, III, IV

4. A parallel plate capacitor is connected to a battery (voltage V) as shown below. A dielectric slab (dielectric constant $\kappa > 1$) can exactly fit between the plates. If the dielectric is inserted which of the following changes occur:



   I. the charge on the plates increases
   II. the voltage across the the plates increases
   III. the energy stored by the capacitor increases
   IV. the electric field in the middle of the capacitor decreases

   A. II, III, IV
   B. I, III
   C. I, IV
   D. I, III, IV

5. In terms of units the equation $P = IV$ reads:

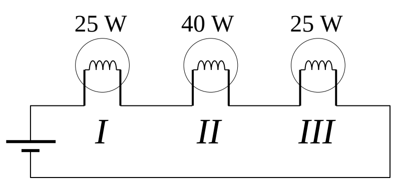
   A. J/s = C/s × J/C

   B. W = Ω × V

   C. W = C/s × N/C

   D. Ω = A × V

6. As shown below a 25 W bulb, a 40 W bulb, and another 25 W bulb are connected in series, Which bulb shines the brightest?



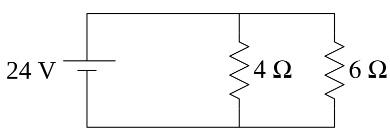
   A. I

   B. II

   C. III

   D. I and III .

7. What is the current through the 6 Ω resistor?



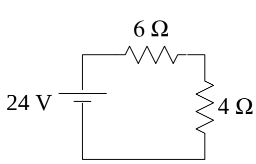
   A. 2.4 A

   B. 3 A

   C. 4 A

   D. 10 A

8. What is the current through the 6 Ω resistor?



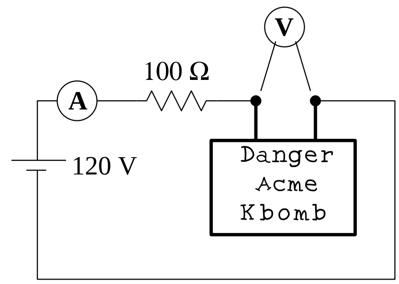
   A. 2.4 A

   B. 3 A

   C. 4 A

   D. 10 A

9. An alien electronic device is found sitting on the ground near Area 51. In an unknown language it is labeled "Danger Acme K-Bomb". Its two terminals are wired into a circuit as shown below. The ammeter reads 0.1 A, the voltmeter is about to be attached. What will the voltmeter read?



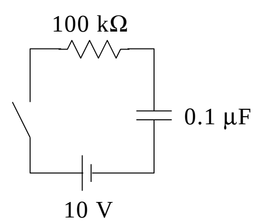
   A. 120 V

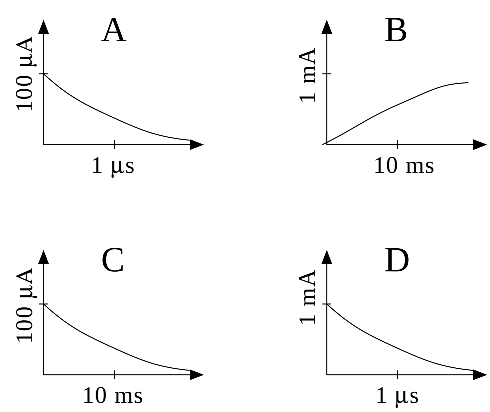
   B. 110 V

   C. 100 V

   D. You can't say without further information

10. The below circuit shows a series RC circuit. The switch is closed at $t = 0$. Which graph best represents how the *current* changes in time?





The following problems are worth 10 points each

11. A 0.01 μF parallel plate capacitor is filled with a dielectric $\kappa = 10$. The area of the plates is 1 cm^2.

    A. What is the separation of the plates?

    B. The dielectric will break down (spark through) if the electric field exceeds 10^7 V/m. How much charge can the capacitor store before it sparks through?

12. The inside of my garage is lighted by twelve lamps each with a 60 W bulb.

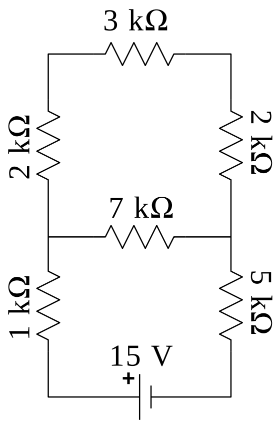
    A. Draw a circuit diagram for the wiring in my garage.

    B. What is the resistance of the 60 W bulb at 120 V?

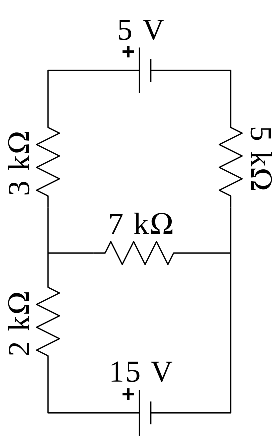
    C. How much total current (at 120 V) do I need to supply to my garage?

    D. If energy costs 5¢ per kW·hr, how much does it cost to light my garage for 4 hours?

13. In the following circuit find the total current flowing through the battery and current through the 3 kΩ resistor. Hints: Direct application of Kirchhoff's laws is not required: you can break this circuit into various fragments for which equivalences can be determined. Work systematically and show your work!



14. Using Kirchhoff's Laws find the current flowing in each wire of the following circuit. In solving this problem you will need to name and show current directions in each wire. Provide these names and directions by writing directly the following circuit diagram. You will also need to apply the loop rule to various loops around this circuit. For each such loop used, clearly show (by writing directly on the following circuit diagram) the loop followed (including direction) and the resulting equation. Feel free to solve these equations using direct calculator methods, but record exactly what data (equations) you intended to type into your calculator. (Otherwise it is very difficult to give partial credit.)



15. In the circuit shown, $\mathcal{E} = 50$ V, $R = 2.2$ kΩ, and $C = 3.3$ μF. The neon lamp L is generally a non-conductor, however, when the voltage across it exceeds 35 V it flashes for an instant (and during that instant it conducts like a wire). What is the time interval between flashes? If all the energy stored in the capacitor just before the flash is dissipated in the neon lamp, what is the *average power* dissipated in the neon lamp over the cycle?