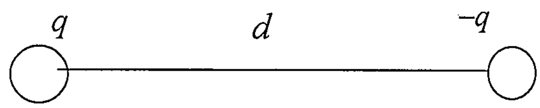
Q1. Multiple Choice:

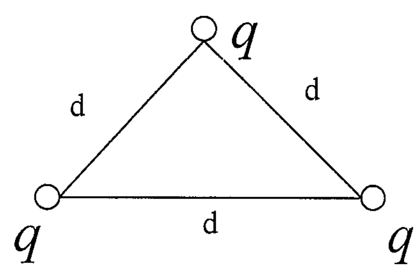
(6 marks)

1. In the following figure, the charge q is ~~the~~ at origin and $-q$ is at distance d from q. Where (other than $\pm\infty$) is the electric potential ~~energy~~ equal to zero?



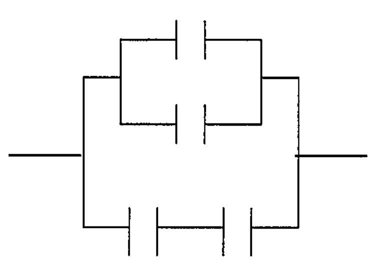
a. 0 b. $\frac{d}{2}$ c. $-\frac{d}{2}$ d. $\frac{3d}{2}$ e. other than that.

2. In the following figure, three charges of equal magnitude are at the corners of an equilateral (equal sided) triangle, how much is the potential at each charge due to the other two charges?



a. $3k\frac{q}{d}$ b. $2k\frac{q}{d}$ c. $3k\frac{q^2}{d}$ d. $2k\frac{q^2}{d}$ e. $3k\frac{q}{d^2}$

3. In the following figure what is the equivalent capacitor for the four identical capacitors each having capacitance C?



a. $\frac{3C}{2}$ F b. $\frac{5C}{4}$ F c. $\frac{3C}{4}$ F d. $\frac{5C}{2}$ F e. other than that

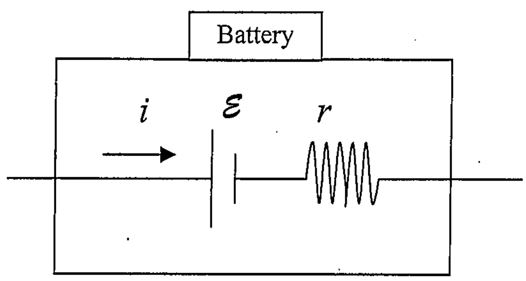
4. If the distance between a square parallel plate capacitor is doubled, by what factor do we need to increase the side of each plate to keep the capacitance constant?

(a.) $\sqrt{2}$ b. $\frac{1}{\sqrt{2}}$ c. 2   d. $\frac{1}{2}$ e. other than that

5. Four resistors are connected in series and other four are connected in parallel. Both combinations are under the same potential difference. The values of the resistors are equal. Which combination dissipates more power?

a. They dissipates equal power
b. Series combination
(c.) Parallel combination
d. No power is dissipated in both
e. cannot be determined without the value of the current.

6. In the following figure, what is the absolute value of the potential difference of the battery?



a. ir b. $\mathcal{E}-ir$ (c.) $\mathcal{E}+ir$ d. $\mathcal{E}$ e. $ir-\mathcal{E}$

Problems:

2. A parallel plate capacitor has plate area of 3.0 cm^2 and separation of 1.0 mm and is connected to a battery with 3.0 V potential difference. The battery is then disconnected and the plates are pulled apart until their separation is doubled.
   a. How much is the new potential difference?
   b. What is the work required to separate the plates?

(4 marks)

a) $q_1 = C_1 V_1$

$$= \left(\frac{\varepsilon_0 \times 3 \times 10^{-4}}{1 \times 10^{-3}} \right)(3) = 8.0 \times 10^{-12}\ C$$

$$q_2 = C_2 V_2 = q_1$$

$$\frac{\varepsilon_0 \times 3 \times 10^{-4}}{2 \times 10^{-3}} V_2 = 8.0 \times 10^{-12} \Rightarrow V_2 = 6\ V$$

b) $W = U_f - U_i$

$$= \frac{1}{2} C_2 V_2^2 - \frac{1}{2} C_1 V_1^2$$

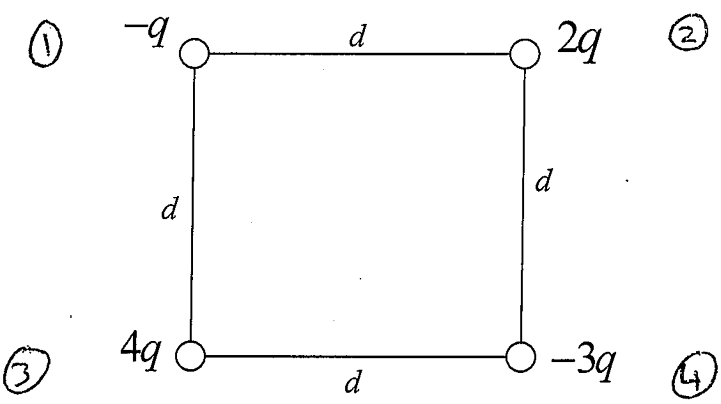
$$= \frac{1}{2} \varepsilon_0 A \left(\frac{V_2^2}{d_2} - \frac{V_1^2}{d_1} \right)$$

$$= \frac{1}{2} \varepsilon_0\ 3 \times 10^{-4} \left(\frac{6^2}{2 \times 10^{-3}} - \frac{3^2}{1 \times 10^{-3}} \right)$$

$$= 1.2 \times 10^{-11}\ J$$

3 Four charges are located at the corners of a square with edge length d. What is the potential energy of the system? Take $q = 3\ \mu\text{C}$, $d = 3$ cm.

(4 marks)

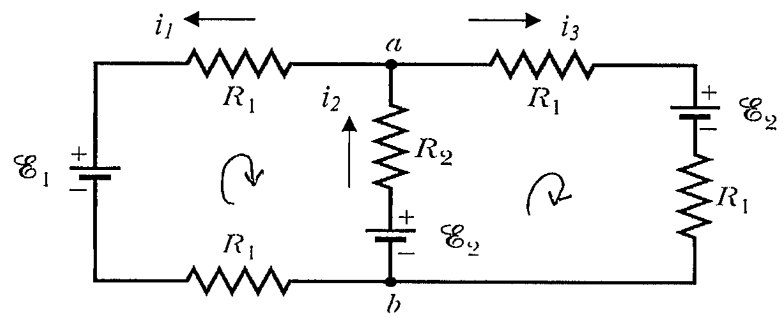


$$U = k\left(\frac{q_1 q_2}{d} + \frac{q_1 q_3}{d} + \frac{q_1 q_4}{\sqrt{2}\,d} + \frac{q_2 q_3}{\sqrt{2}\,d} + \frac{q_2 q_4}{d} + \frac{q_3 q_4}{d} \right)$$

$$= \frac{kq^2}{d}\left(-2 - 4 + \frac{3}{\sqrt{2}} + \frac{8}{\sqrt{2}} - 6 - 12 \right)$$

$$= -43.8\ \text{J}$$

4 The elements in the following circuit have the following values:
$\mathcal{E}_1$=3.0 V, $\mathcal{E}_2$=6.0 V, R_1=2.0 Ω, R_2=4.0 Ω.
Find the magnitude and direction of the current in each of the three branches.



(6 marks)

$$i_2 = i_1 + i_3 \quad \cdots (1)$$

Left loop: $\Delta V = \mathcal{E}_1 + i_1 R_1 + i_2 R_2 - \mathcal{E}_2 + i_1 R_1 = 0$

$$= 4 i_1 + 4 i_2 - 3 = 0 \quad \cdots (2)$$

Right loop: $\Delta V = \mathcal{E}_2 - i_2 R_2 - i_3 R_1 - \mathcal{E}_2 - i_3 R_1 = 0$

$$= -4 i_3 - 4 i_2 = 0$$

$$\Rightarrow i_2 = -i_3 \quad \cdots (3)$$

Substituting (3) in (1)

$$i_2 = i_1 - i_2 \Rightarrow i_1 = 2 i_2$$

substituting in (2)

$$4 i_1 + 2 i_1 - 3 = 0 \Rightarrow i_1 = 0.5\ A$$

$$i_2 = 0.25\ A$$

$$i_3 = -0.25\ A$$