1. A particle with charge $Q = +5.00\ \mu C$ is located at the center of a cube of edge $L = 0.120$ m. In addition, six other identical charged particles having $q = -1.00\ \mu C$ are positioned symmetrically around Q as shown in the figure below.

(i) Which of the following statements is FALSE?

TRUE! See below → A) The net electric flux through all six faces of the cube is negative.

B) The magnitude/size of the electric field on each face of the cube is constant.

TRUE! Φ_E does not depend on shape of surface → C) If the size of the cube were doubled, the net electric flux through all six faces would remain unchanged.

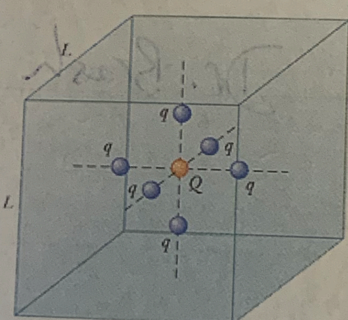
D) If the size of each charge within the cube were doubled, the net electric flux through all six faces would also be doubled.

TRUE! $\Phi_E^{TOTAL} \propto Q_{enclosed}$

NOT TRUE! $\vec{E}$ is not constant for this symmetry.

(ii) Determine the electric flux through one face of the cube.

(iii) What value of the central charge, Q, would cause the net electric flux through all six faces to be zero? Explain your answer!



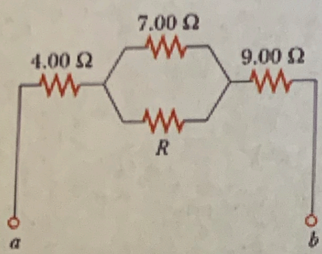
(ii) $$\Phi^{TOTAL}_{\substack{CLOSED\\SURFACE}} = \frac{Q_{enclosed}}{\varepsilon_0} = \frac{Q + 6q}{\varepsilon_0} = \frac{5\mu C + 6(-1\mu C)}{\varepsilon_0}$$

$$= \frac{-1\mu C}{\varepsilon_0} = \frac{-1\times10^{-6}\ C}{8.854\times10^{-12}\ \frac{C^2}{N\cdot m^2}} = -1.13\times10^{5}\ \frac{N\cdot m^2}{C}$$

(iii) For $\Phi_E^{TOTAL} = 0$, $Q_{enclosed} = 0$ $\therefore$ $Q = -6q$

$= 6\mu C$

2. Consider the following group of resistors:



(i) The value of resistance for a particular resistor does NOT depend on which of the following quantities?

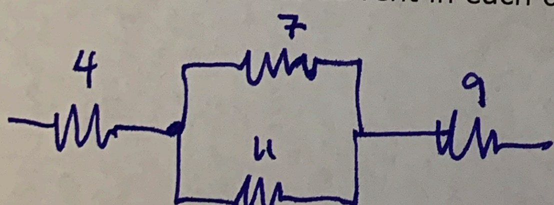
~~A)~~ The length of the resistor
B) The current through the resistor
~~C)~~ The diameter of the resistor
~~D)~~ The material from which the resistor is made

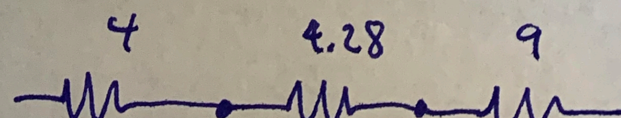
$R = \rho l / A$

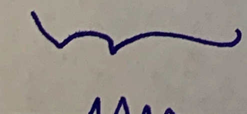
$\therefore$ R depends on l, d, and material.

(ii) Find the equivalent resistance between points *a* and *b*, assuming *R* = 11.0 Ohms.

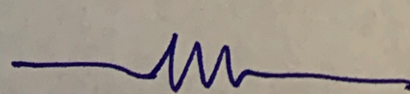
(iii) A battery with a voltage of 34.0 V is connected between points *a* and *b*. Calculate the current in each of the four resistors.





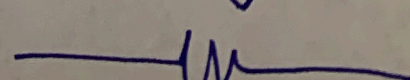


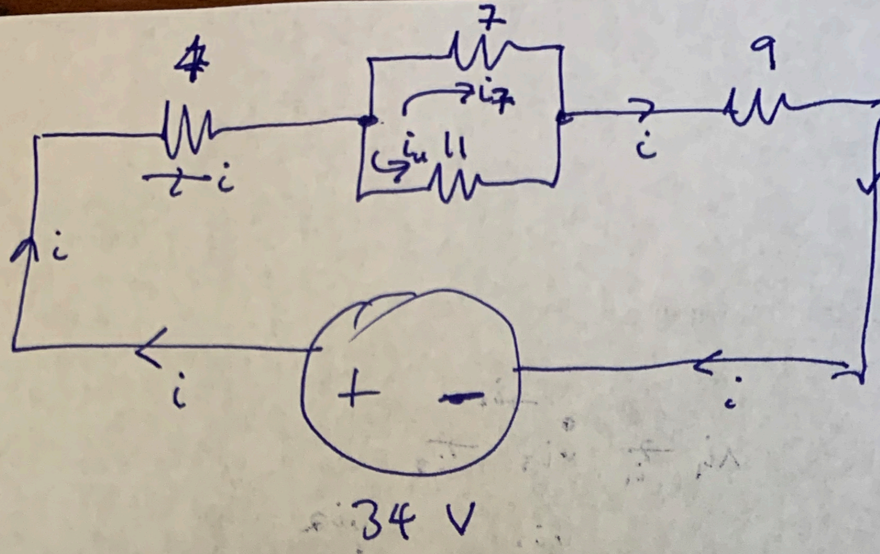
$$\frac{1}{\frac{1}{7} + \frac{1}{11}} = 4.28\,\Omega$$



$4 + 4.28 + 9$

$\boxed{R_{equiv} = 17.28\,\Omega}$





$$i = \frac{\Delta V}{R_{equivalent}} = \frac{34\ V}{17.28\ A} = 1.97\ A$$

$$i_7 + i_{11} = 1.97 \quad ①$$

$$7 i_7 = 11 i_{11} \quad (\Delta V_{top} = \Delta V_{bottom}) \quad ②$$

$$\therefore\ i_7 = \frac{11}{7} i_{11} \qquad \frac{11}{7} i_{11} + i_{11} = 1.97$$

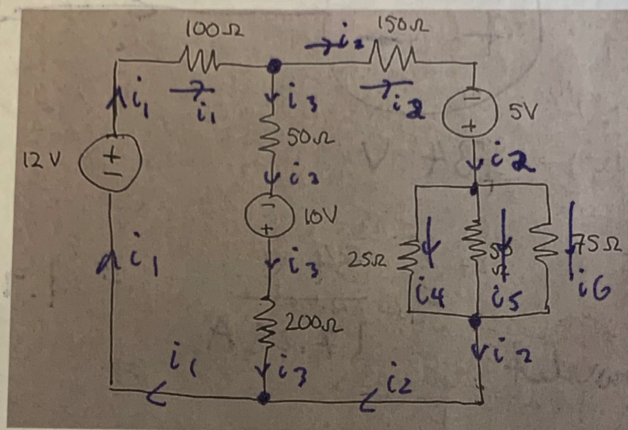
$$\frac{18}{7} i_{11} = 1.97$$

$$i_{11} = \frac{7}{18}(1.97) = 0.77\ A$$

$$i_7 = \frac{11}{7} \cdot i_{11} = 1.20\ A$$

$$\boxed{i_4 = 1.97\ A\ ,\quad i_7 = 1.20\ A\ ,\quad i_{11} = 0.77\ A\ ,\quad i_9 = 1.97\ A}$$

3. Consider the following circuit:



(i) Thinking about the size of the current in each resistor, which of the following statements is correct?

~~A) $I_{25} > I_{75} > I_{150} > I_{100}$~~
~~B) $I_{75} > I_{25} > I_{150} > I_{100}$~~
~~C) $I_{150} > I_{100} > I_{75} > I_{25}$~~
~~D) $I_{100} > I_{150} > I_{75} > I_{25}$~~
E) $I_{100} > I_{150} > I_{25} > I_{75}$

① Since i_1 splits into i_2 and i_3,
$i_1 > i_2$ ∴ $i_{100} > i_{150}$
A, B, C are wrong!
② current takes path of least resistance!
∴ $i_{25} > i_{75}$

(ii) Redraw the above circuit, and label this new diagram to show how the current travels throughout the circuit. See above.

(iii) Using Kirchoff's Junction Rule, write down the appropriate set of equations that describe the relationships between the various currents in the circuit.

(iv) Using Kirchoff's Loop Rule, write down the additional equations necessary to solve for all currents in the circuit. How many more equations are needed, and why?

(iii) $i_1 = i_2 + i_3$ ① $\quad i_2 = i_4 + i_5 + i_6$ ②

(iv) Need 4 more → 6 equations in 6 unknowns
$i_1 \dots i_6$

(3) $12 - 100i_1 - 50i_3 + 10 - 200i_3 = 0$

(4) $12 - 100i_1 - 150i_2 + 5 - 25i_4 = 0$

(5) $12 - 100i_1 - 150i_2 + 5 - 50i_5 = 0$

(6) $12 - 100i_1 - 150i_2 + 5 - 75i_6 = 0$