1. In the circuit diagram shown, what is the voltage of the unknown battery if no current flows through the 20 Ω resistor?

Assume $I_1$, flows through 10 Ω from left to right, $I_2$ flows through 20 Ω from up to down, and $I_3$ through 30 Ω from left to right.

Left loop: \[ E - I_1 \times 10 + I_2 \times 20 = 0 \]

\[ \Rightarrow I_2 = 0 \]

Current Rule: $I_1 = I_2 + I_3$\[ I_1 = I_3 \]

Right loop: \[ -10 - I_3 \times 30 + I_2 \times 20 = 0 \]

\[ \Rightarrow I_3 = \frac{-1}{3} A \]

\[ \Rightarrow I_1 = \frac{-1}{3} A \]

Use eqn (1) \[ E = \left( -\frac{1}{3} \right) \times 10 = 0 \]

\[ \Rightarrow E = -\frac{10}{3} V \] (Opposite polarity).

2. A cylindrical wire of radius 2 cm and length 10 cm, has resistivity $10^{-8}$ Ω·m.

i.) Find the resistance of the wire. If this wire is then melted and converted into 4 cylindrical wires with the same length. 

ii.) Find the resistance of each of these new wires.

iii.) Find the equivalent resistance when all 4 of these are connected in parallel. How does this equivalent resistance compare with the resistance of the original wire? Explain why.

\[ R = \frac{\pi L}{A} \]

\[ \text{Volume of the 4 new wires} = \text{Old wire's volume} \]

\[ 4 \times \pi \left( \frac{2}{2} \right)^2 L = \pi \times \frac{2^2}{2} L \]

\[ \Rightarrow 4 \times \pi \text{new} = \pi \text{old} \]

\[ \Rightarrow 4 \times \text{new} = \frac{\pi \text{old}}{2} \]

\[ \Rightarrow \frac{\pi \text{new}}{4} = \frac{\pi \text{old}}{8} \]

\[ \Rightarrow \text{Req} = \frac{1}{4} \text{R}_{\text{new}} = \frac{\pi \text{new} L}{4 \times \pi \text{new} \times \frac{\pi \text{old}}{2}} = \frac{8L}{\pi \text{old}^2} \]

Thus $\text{Req} = R_{\text{old}}$.

This makes sense, since 4 wires in parallel is the same as old wire. 

\[ \text{Old wire} = \text{New wire} \]