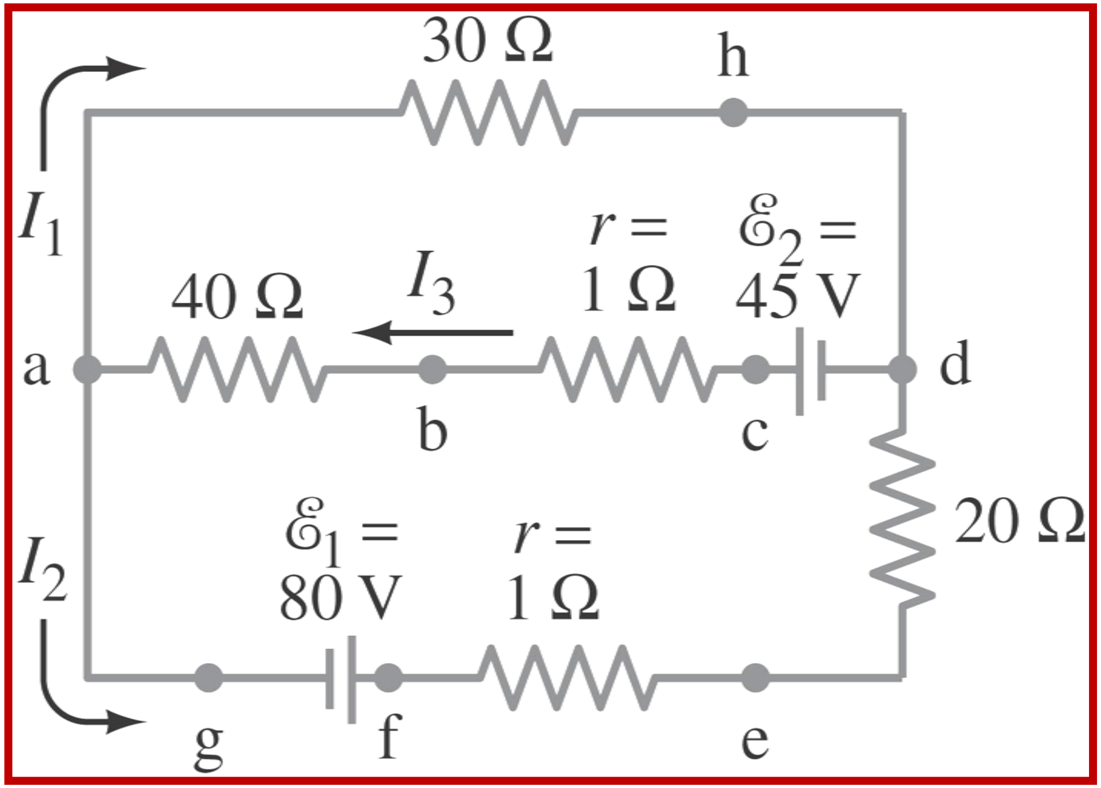
Kirchhoff’s Rules

Experiment 6

Kirchhoff's Rules

- Some circuits cannot be broken down into series & parallel connections. For these circuits we use

***Kirchhoff's Rules*.**



Kirchhoff's Rules:
Their Underlying Physics

1. Kirchhoff's Junction Rule (***First Rule***):
At a junction point, the sum of all currents entering the junction equals the sum of all currents leaving it.

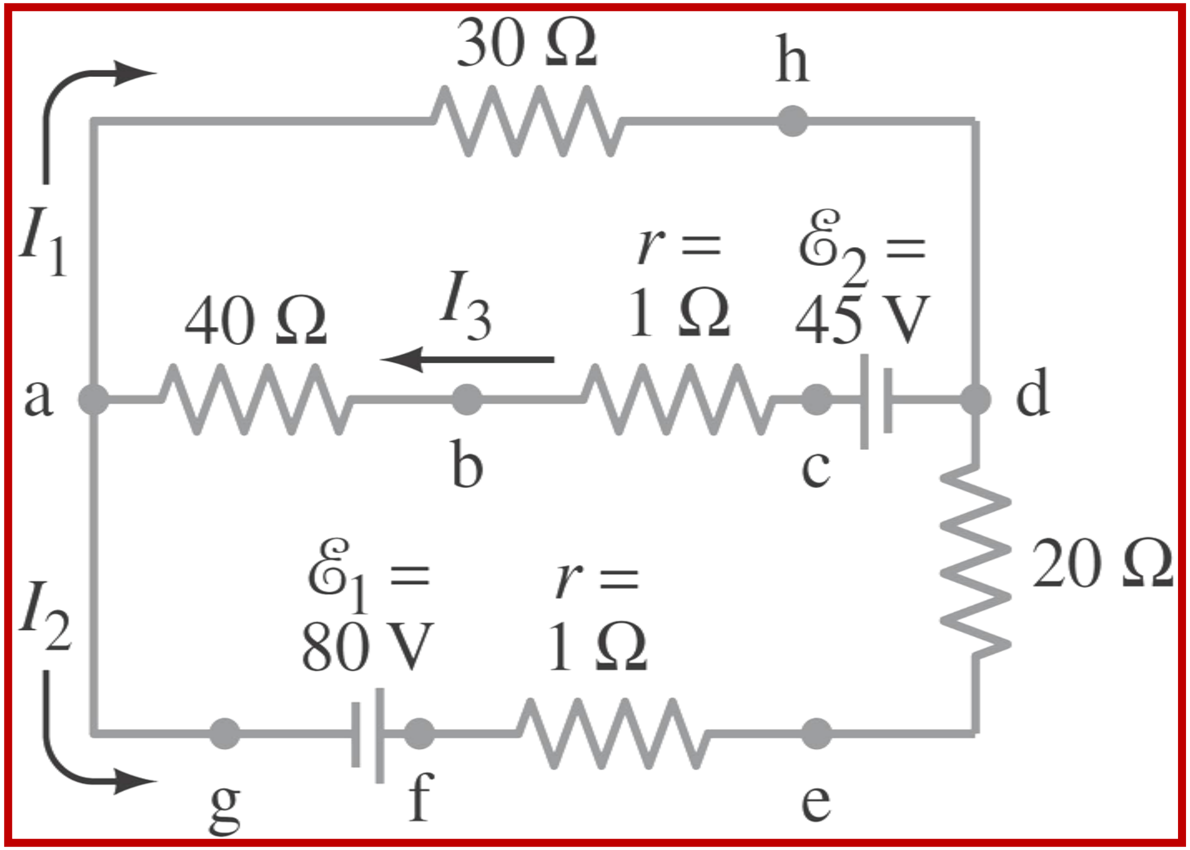
Physics: Conservation of Electric Charge.

2. Kirchhoff's Loop Rule (***Second Rule***):
The sum of the changes in Electric Potential **ΔV** around any closed loop in a circuit is zero.

Physics: Conservation of Energy in the Circuit.

Kirchhoff's Junction Rule

- The sum of the currents entering a junction equals the sum of the currents leaving it.

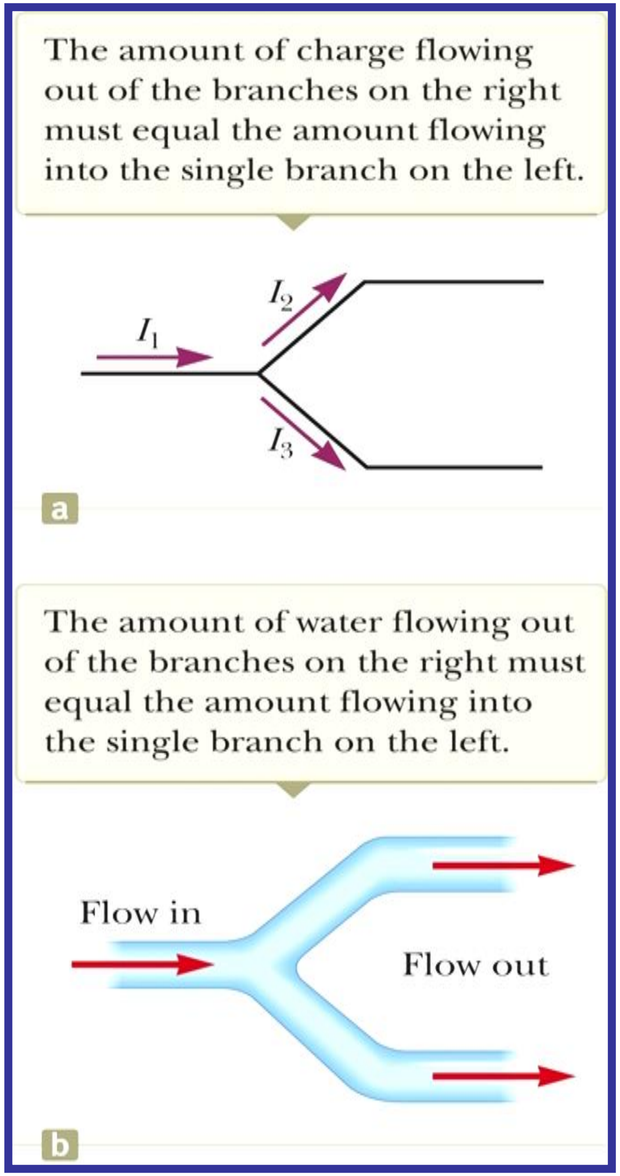


Kirchhoff's Junction Rule

The sum of currents entering a junction equals the sum of the currents leaving it.

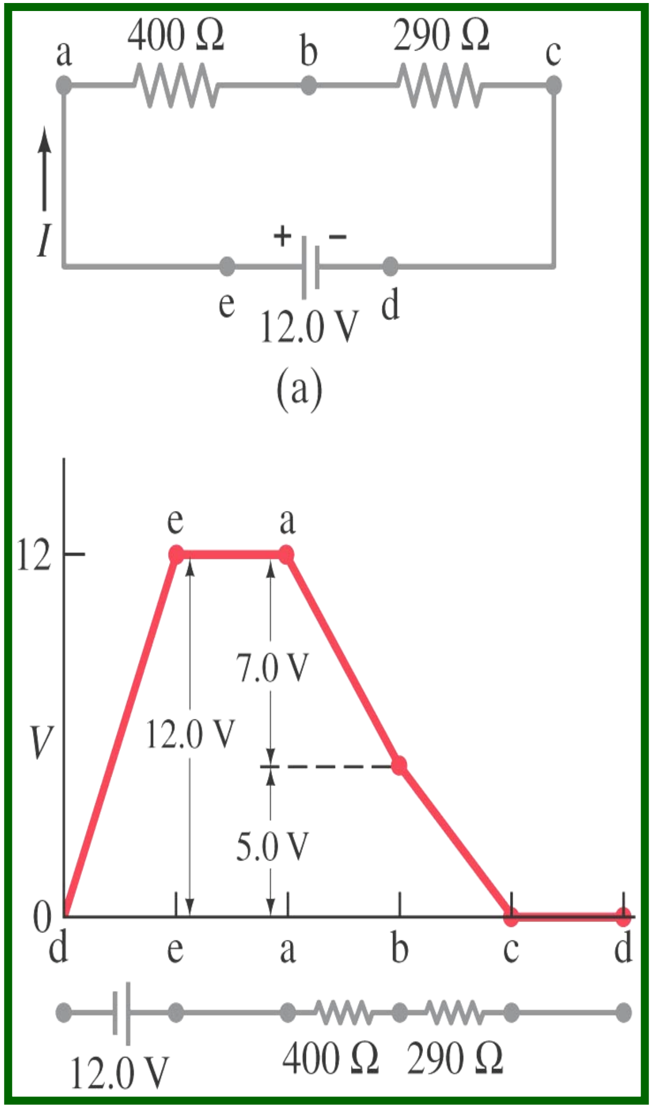
- Currents directed into the junction are entered into the equation as **+I** and those leaving as **-I.**
- This is analogous to water flowing in pipes at a junction.

See figure.



Kirchhoff's Loop Rule

The sum of the changes in Electric Potential ΔV around any closed loop in a circuit is zero.



Example: Using Kirchhoff's rules.

Calculate the currents I_1, I_2, and I_3 in the three branches of the circuit in the figure.

K C L at junction a

I3= I1 + I2 ---------- 1

KVL (agedcba)

$\Sigma \Delta V = 0$

$-80 + 21 I_2 - 45 + 41 I_3 = 0$ -- 2

$125 = 21 I_2 + 41 I_3$ ---- 2*

KVL (ahdcba)

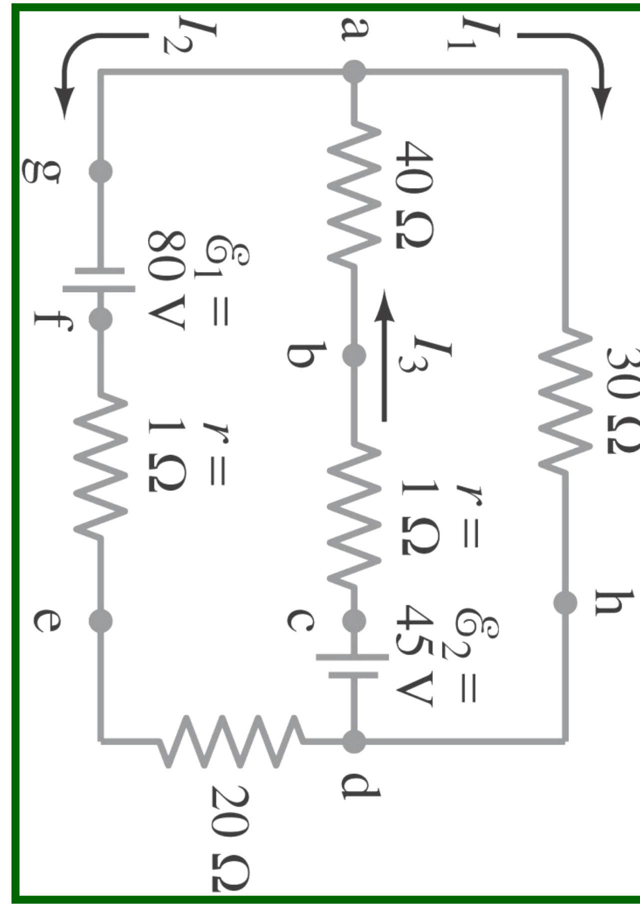
$\Sigma \Delta V = 0$

$-45 + 41 I_3 + 30 I_1 = 0$ -- 3

$45 = 41 I_3 + 30 I_1$ ---- 3*

Solve the equations

$I_1 = -0.87$, $I_2 = 2.6A$, $I_3 = 1.7A$

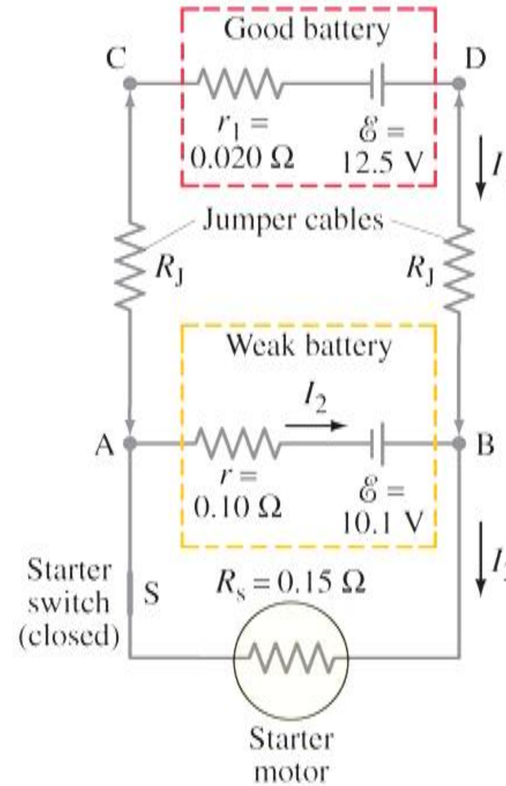


Example: Jump starting a car.

A good car battery is being used to jump start a car with a weak battery. The good battery has an emf of $\mathcal{E}_1$ **= 12.5 V** & internal resistance **r_1 = 0.020 Ω**. Suppose that the weak battery has an emf of $\mathcal{E}_2$ **= 10.1 V** and internal resistance **r_2 = 0.10 Ω**. Each copper jumper cable is **3.0 m** long and **0.50 cm** in diameter, and can be attached as shown. Assume that the starter motor can be represented as a resistor **R_s = 0.15 Ω**. **Calculate** the current through the starter motor:

(a) if only the weak battery is connected to it,

(b) if the good battery is also connected.

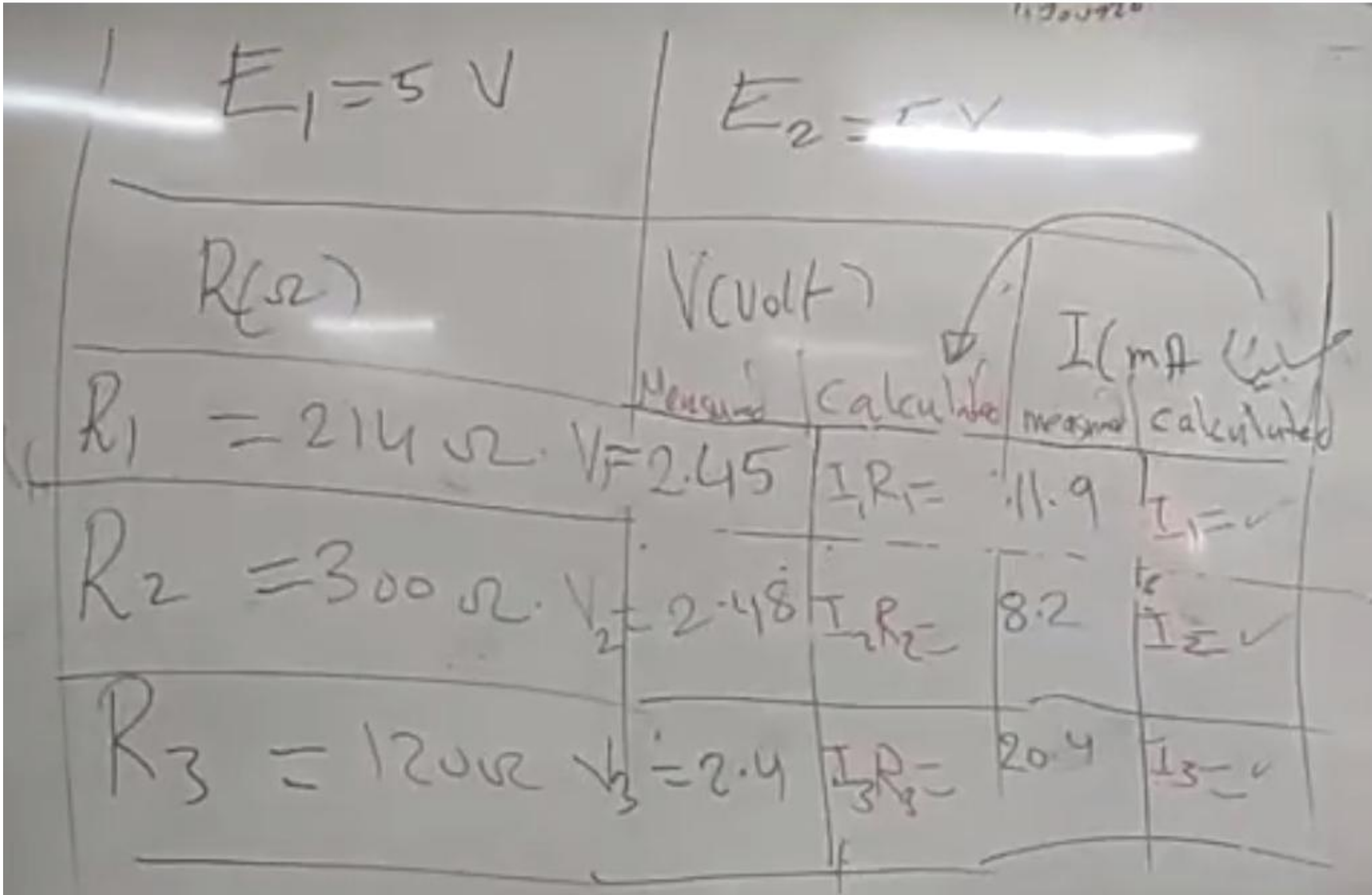


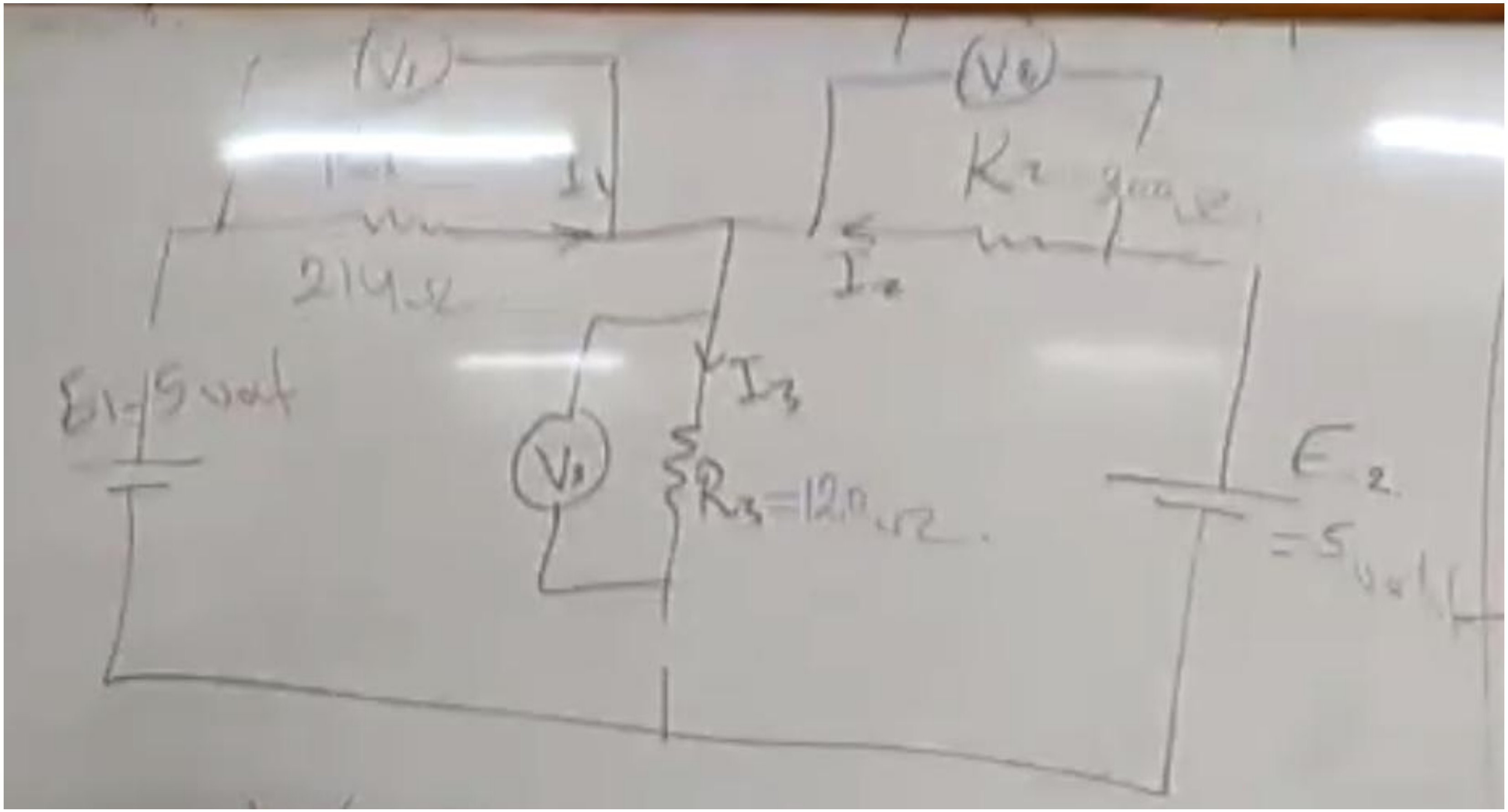
Solution:

a. The weak battery is connected to two resistances in series; I = 40 A.

b. First, find the resistance of the jumper cables; it is 0.0026 Ω. Now this is a problem similar to Example 26-9; you will need three equations to find the three (unknown) currents. (Technically you only have to find the current through the starter motor, but you still need three equations). The current works out to be 71 A

Data of Experiment from Recording video (see Recording)




V1
V2
V3
I3
R3=120 Ω
E2
=5 volt