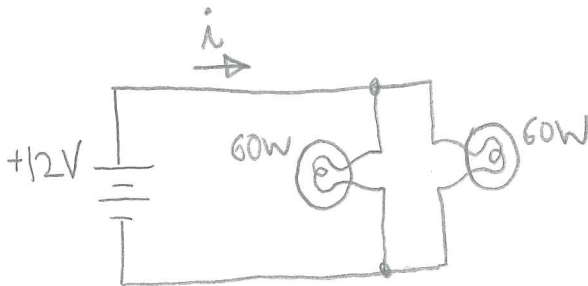


Physics 261
Exam 1

Remember to show your work.

Name: SOLUTIONS

1. (6 points) A 12V car battery contains 2×10^5 Coulombs of charge. Two 60 W headlights are left on, connected in parallel to the battery. Assuming the battery voltage remains constant, how long will it take to completely discharge on the battery?



WE REALLY WANT TO FIND i , BECAUSE $i = \frac{\Delta Q}{\Delta t}$

TIME TO DISCHARGE = Δt ,

AVAILABLE CHARGE = ΔQ .

POWER DISSIPATED IN EACH HEADLAMP:

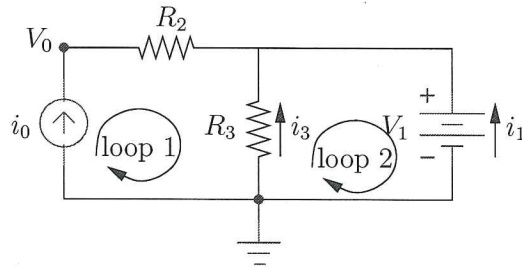
$$P = 60W = i_{\text{LAMP}} V$$

$$i_{\text{LAMP}} = 60W / 12V = 5A$$

$$i = 2 i_{\text{LAMP}} = 10A$$

$$\therefore \Delta t = \frac{2 \times 10^5 C}{10A} = 2 \times 10^4 s.$$

2. In the circuit below, i_0 , V_1 , R_2 , and R_3 are known.



- (a) (2 points) What is the current through R_2 ?
- (b) (4 points) Write Kirchoff's voltage law for loops 1 and 2.
- (c) (2 points) Write Kirchoff's current law for the node at the top.
- (d) (6 points) Solve for V_0 , i_1 , and i_3 in terms of known quantities.

(a) CURRENT THROUGH R_2 IS i_0 .

(b) ① $V_0 - i_0 R_2 + i_3 R_3 = 0$

② $-i_3 R_3 - V_1 = 0$

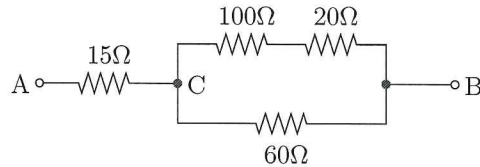
(c) $i_0 + i_3 + i_1 = 0$

(d) $i_3 = \frac{-V_1}{R_3}$

$i_1 = -i_0 - i_3 = -i_0 + \frac{V_1}{R_3}$

$V_0 = i_0 R_2 - i_3 R_3 = i_0 R_2 + V_1$

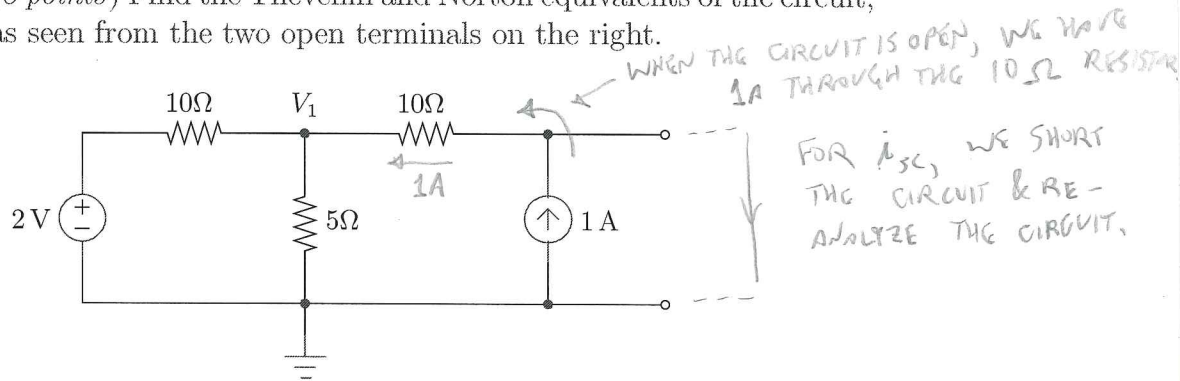
3. (a) (4 points) Find the equivalent resistance from A to B.
 (b) (4 points) Suppose +11 V is connected at A, and ground at B.
 Find the voltage at C.



$$\begin{aligned}
 \text{(a)} \quad R_{\text{Eq}} &= 15\Omega + \frac{1}{\frac{1}{60\Omega} + \frac{1}{100\Omega + 20\Omega}} = 15\Omega + \frac{120\Omega}{2+1} \\
 &= 15\Omega + 40\Omega = \boxed{55\Omega}
 \end{aligned}$$

$$\begin{aligned}
 \text{(b)} \quad V_C &= 11V \left(\frac{40\Omega}{40\Omega + 15\Omega} \right) \\
 &= \boxed{8V}
 \end{aligned}$$

4. (a) (4 points) Solve for V_1 using Node Voltage Analysis.
 (b) (8 points) Find the Thevenin and Norton equivalents of the circuit, as seen from the two open terminals on the right.



(a) FOR NVA, WE USE KCL; USING OHM'S LAW WHERE NEEDED:

$$\frac{2V - V_1}{10\Omega} + \frac{0 - V_1}{5\Omega} + 1A = 0$$

$$\Rightarrow 2V - V_1 - 2V_1 + 10V = 0 \Rightarrow V_1 = 4V$$

(b) $V_{oc} = V_1 + 10\Omega \cdot 1A = 4V + 10V = 14V$ (OPEN CIRCUIT VOLTAGE)

V_1 CHANGES WHEN THE TERMINALS ARE SHORTED:

$$\frac{2V - V_1}{10\Omega} + \frac{0 - V_1}{5\Omega} + \frac{0 - V_1}{10\Omega} = 0 \Rightarrow V_1 = 0.5V$$

TO FIND i_{sc} , USE KCL:

$$\frac{V_1 - 0}{10\Omega} + 1A - i_{sc} = 0 \Rightarrow i_{sc} = 1.05A$$

THEVENIN:

$$V_{TH} = V_{oc} = 14V$$

$$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{14V}{1.05A} = 13.3\Omega$$

NORTON:

$$I_N = I_{sc} = 1.05A$$

$$R_N = R_{TH} = 13.3\Omega$$

