Name Rubrik SID

EE42/100 Midterm 1

-1 for missing/wrong units
-3 for gross calculation error

NO CALCULATORS, CELL PHONES, or other electronics allowed. Show your work, and put final answers in the boxes provided. Use proper units in all answers.

1. [5] You have a copper trace on a Printed Circuit Board that is 10cm long and 1mm wide. The thickness of the copper is 0.1mm. The resistivity of copper is 1.7×10^{-8} Ohm-m. Calculate the resistance of the wire.

$$\rho\frac{L}{A} = 1.7\times10^{-8}\frac{10^{-1}}{10^{-3}10^{-4}} = 1.7\times10^{-2}\,\Omega$$

R = 17mΩ

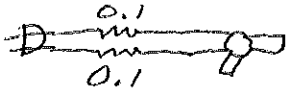
2. [10] An electric car has a rechargeable battery with a capacity of 60kWh. A standard J1772 charger supplies 30A at 200V. What is the power output of the charger (use the correct units)? If the battery is completely empty, how long does it take to fully charge it from the J1772 charger?

$$P = IV = (30A)(200V) = 6kW$$
$$T = \frac{E}{P} = \frac{60kWh}{6kW} = 10h$$

P = 6kW T = 10h

3. [10] You have a hair dryer that is rated at 1,200W. You plug it into a 3-wire extension cord. Each wire in the extension cord has a resistance of 0.1 Ohms. You plug the extension cord into an ideal 120V outlet. Estimate the current in the hair dryer, and the power dissipated in the extension cord.

$$I = \frac{P}{V} = \frac{1200}{120} = 10A$$



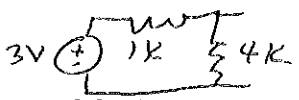
$$P_{cord} = 2(10A)^2(0.1\Omega) = 20W$$

I = 10A P = 20W

10W -2
30W -2

4. [10] A lithium coin cell battery has a Thevenin equivalent circuit model with V_{eq}=3V and R_{eq}=1kΩ. What is the current that will flow if you short-circuit the battery? You connect the battery to a 4kΩ resistive load. What is the voltage that will appear across the load?

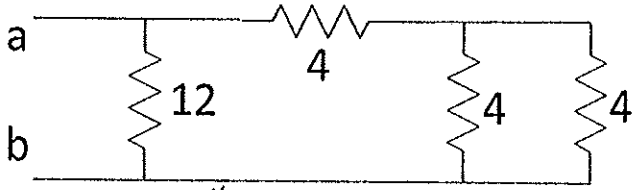
$$I_{sc} = \frac{3V}{1K} = 3mA$$

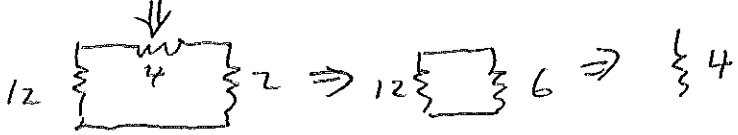


$$V_{load} = 3V\,\frac{4K}{1K+4K} = 3V(0.8)$$

I = 3mA V = 2.4V

5. [5] What is the resistance between nodes a and b in the figure below?





R = 4Ω

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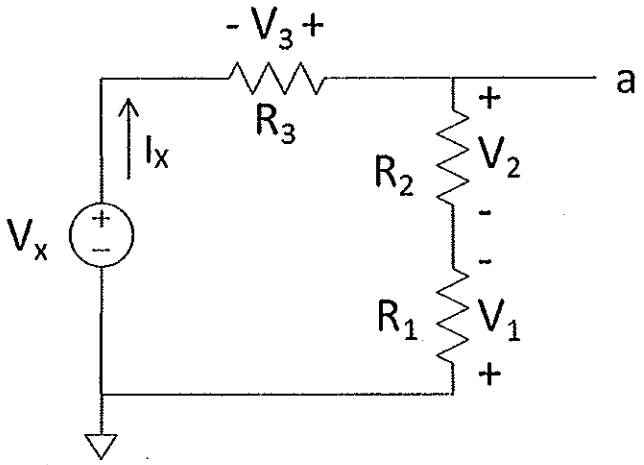
6. [20] For the figure below, write an expression for the voltage at node a in terms of V1 and V2 only. Write an expression for the voltage at node a in terms of Vx and V3 only. Write an expression for V1 in terms of Ix and R1 only. Write an expression for V2 in terms of Ix and R2 only.



Va(V1,V2)= $-V_1+V_2$ signs 4

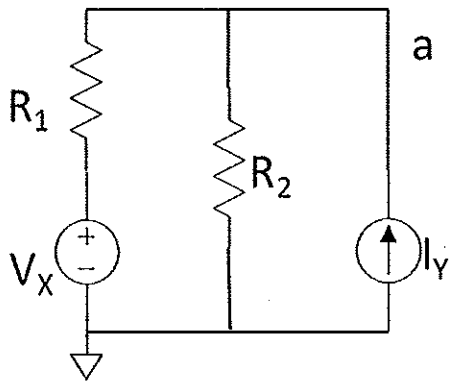
Va(Vx,V3)= V_x+V_3 sign 4

V1(Ix,R1)= $-I_xR_1$ signs 4

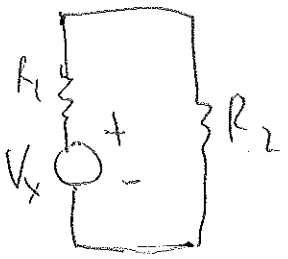
V2(Ix,R2)= I_xR_2 signs 4

* If relationship wrong no credit

7. [20] Use superposition to calculate the voltage at node a in the figure below by
   a. drawing the two simplified circuits corresponding to the individual independent sources
   b. solving for the effect of each source and writing the equation for the output as a function of the independent sources

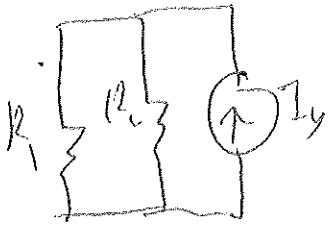


Vx circuit



5

Iy circuit



5

Va(Vx,Iy)= $I_y\frac{R_1R_2}{R_1+R_2}+V_x\frac{R_2}{R_1+R_2}$

5 5

If unit wrong, 0, If unit right, 1/2 or

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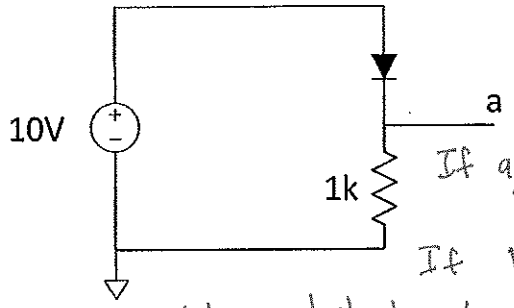
8. [25] You measure the performance of several identical diodes and find that they each pass 0.1mA of current at a forward bias of 0.6V.

   a. Estimate the bias necessary to get a diode to pass 1mA of current.

   b. Estimate the voltage at node a in the circuit below to within 10mV.



Vd(1mA) = 660mV = 0.66V (+5)

↳ All or nothing unless off by obvious factor of 10. (+2)

ii) Wrote down $I_D = I_S\, 10^{V_d/60mV}$; $I_d = \frac{10-V_d}{1k}$ (+1)

If assumed 1mA → V_d = 0.66V

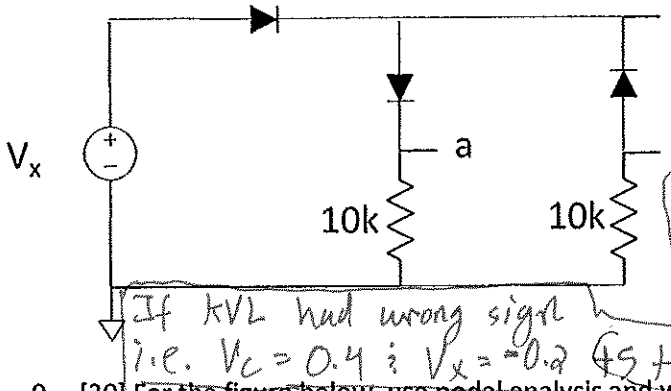
V_a = 9.34 (+2)

If V_a = 1mA(1k) or .1mA(1k) (+0)

Wrong but tried guessing technique (+3)

Va= 9.28V (+5)

   c. Given that the voltage at node a in the circuit below is 1V, estimate the voltage at nodes b and c, and the value of Vx.



All or nothing → Vb= (+5) 0 or 10^{-14} : 1×10^{-7} = 10^{-10}

Vc= (+5) 1.6V

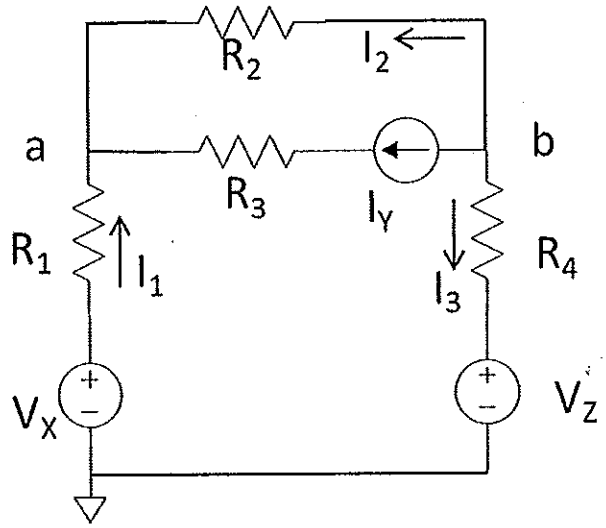
Vx= (+5) 2.2V

If got $V_c = 1 + V_d$ and $V_x = 1 + 2V_d$ but used wrong V_D : (+5) total

if used V_b = 0.66V (+7) Total

If KVL had wrong sign i.e. V_c = 0.4 ; V_x = −0.2 (+5 total)

9. [30] For the figure below, use nodal analysis and write the node voltage equations for the two extraordinary nodes. Equations should contain node voltages, resistors, and independent sources.



$I_1 + I_Y + I_2 = 0$

node a $\frac{V_x - V_a}{R_1} + I_y + \frac{V_b - V_a}{R_2} = 0$

$I_2 + I_Y + I_3 = 0$

node b $\frac{V_b - V_a}{R_2} + I_y + \frac{V_b - V_z}{R_4} = 0$

5 pts per term

−1 if no = sign

−2 for wrong sign

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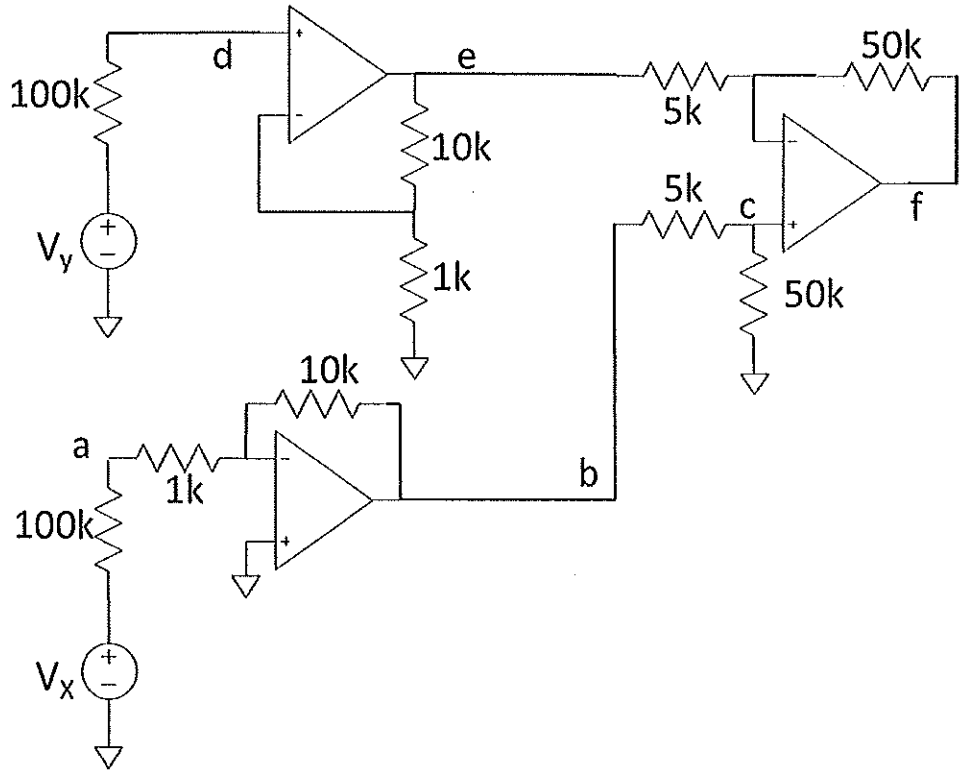
10. [35] In the op-amp circuit below, find the gain from Vx to a, from a to b, from b to c, and so on.



Gain from Vx to a (= Va / Vx) (this might be the hardest one)	$\frac{1k}{101k}$ ~~wrong~~	$\frac{1}{100}$ -1 $\frac{100}{101}$ -3
Gain from Va to Vb (= Vb/Va)	$-\frac{10k}{1k} = -10$	10 -2
Gain from Vb to Vc (= Vc/Vb)	$\frac{50k}{55k} = \frac{50}{55} = \frac{10}{11}$	$\frac{11}{10}$ -2 $\frac{1}{11}$ -3
Gain from Vc to Vf (= Vf/Vc)	$\frac{55k}{5k} = 11$	10 -2
Gain from Vy to Vd (= Vd/Vy)	1	
Gain from Vd to Ve (= Ve/Vd)	$\frac{11k}{1k} = 11$	-11 -2 10 -3
Gain from Ve to Vf (= Vf/Ve)	$-\frac{50k}{5k} = -10$	-11 -2 10 -2

+other terms e.g. $\frac{V_3}{V_e}$ -2