1. [2 pts x 5 = 10 pts] True or False. No explanations are necessary.
   a) The internal resistance *R* of a practical current source is in parallel with the source.
   b) For a well-designed circuit with a practical current source, the internal resistance *R* of the current source should be much larger than the load resistance.
   c) The input resistance of an ammeter is very small.
   d) When we calculate the Thevenin Equivalent circuit, the dependent sources must be turned off.
   e) The input resistance of an operational amplifier is very small.

	a)	b)	c)	d)	e)
True (T) or False (F)	T	T	T	F	F

2. [28 pts] Problems with short answers.
   a) [2 pts] 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 $1.7\text{x}10^{-8}\Omega \cdot \text{m}$. Calculate the resistance of the copper wire.

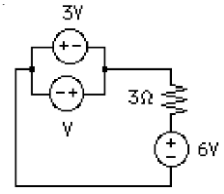
R = 17 m Ω

   b) [4 pts] An electric car has a rechargeable battery with a capacity of 60kWh. A standard J1772 charger supplies 30A at 200V. What is the output power of the charger (use the correct units)? If the battery is completely empty, how long does it take to fully charge the battery using the J1772 charger?

Power = 6KW

Time = 10h

   c) [2 pts] Find the voltage V of the voltage source in parallel with the 3V voltage source in the circuit below.



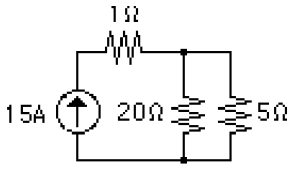
V = -3V

   d) [4 pts] You have two resistors R_1 and R_2. Using these two resistors in various combinations you can get resistances of 4, 6, 12 and 18Ω. Find R_1 and R_2.

R_1 = 6 Ω

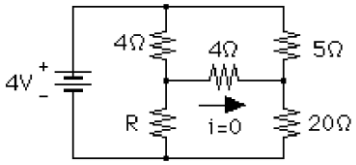
R_2 = 12 Ω

e) [4 pts] Calculate the power dissipated in the 5Ω resistor.



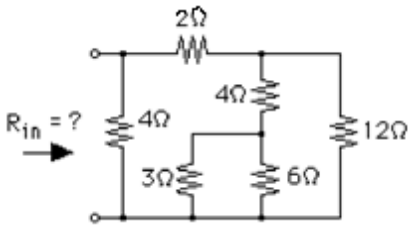
Power =	720	W

f) [4 pts] Find R in the circuit below.



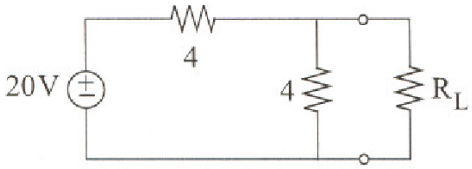
R =	16	Ω

g) [4 pts] Find R_{in} in the circuit below.



R_{in} =	2.4	Ω

h) [4 pts] In the circuit below (resistance is in ohms), for what value of R_L is power in R_L maximized? What's the maximum power dissipated in R_L?



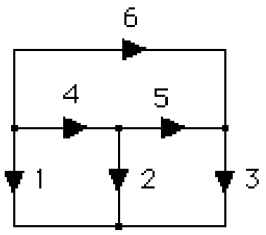
R_L =	2	Ω

Max power =	12.5	W

3. [6 pts] Apply KCL to show that

$$I_1 + I_4 - I_5 + I_3 = 0$$

in the circuit below. Here I_k is the current of branch k $(k = 1, 2, \cdots, 6)$ and its direction is shown in the circuit.

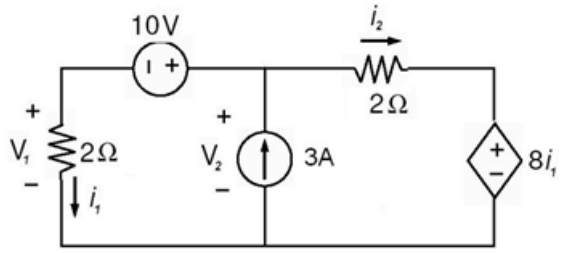


$$-I_6 = I_1 + I_4$$

$$I_6 = -I_5 + I_3$$

$$0 = I_1 + I_4 - I_5 + I_3$$

4. [16 pts] In the circuit shown below



(a) [2 pts] Express i_1 in terms of V_1 and constants given in this problem.

$$V_1 = 2\, i_1$$

(b) [4 pts] Express i_2 in terms of V_1, V_2 and/or constants given in this problem.

$$i_2 = 3 - V_1/2$$

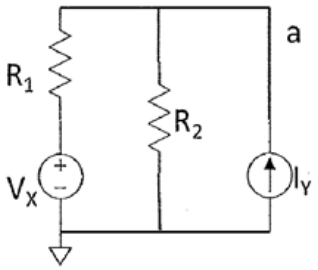
(c) [6 pts] Write two equations in V_1 and V_2 that can be used to solve the circuit.

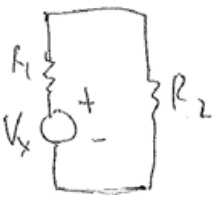
$$10 + V_1 - V_2 = 0$$
$$2 \times (3 - V_1/2) + 8 \times (V_1/2) - V_2 = 0$$

(d) [4 pts] Solve for V_1, V_2, i_1 and i_2.

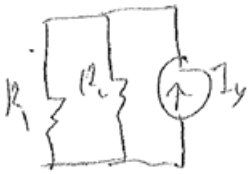
$V_1 = 2$ V
$V_1 = 12$ V
$i_1 = 1$ A
$i_2 = 2$ A

5. [12 pts] Use superposition to <u>calculate the voltage at node a</u> 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 equations for the output as a function of the independent sources.





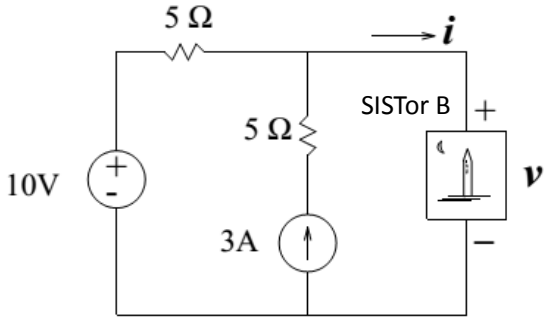
V_X circuit

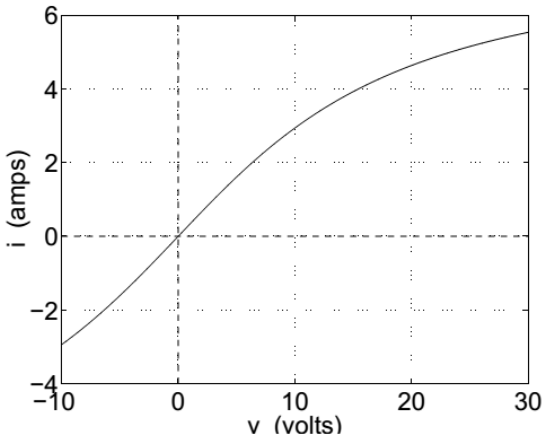


I_Y circuit

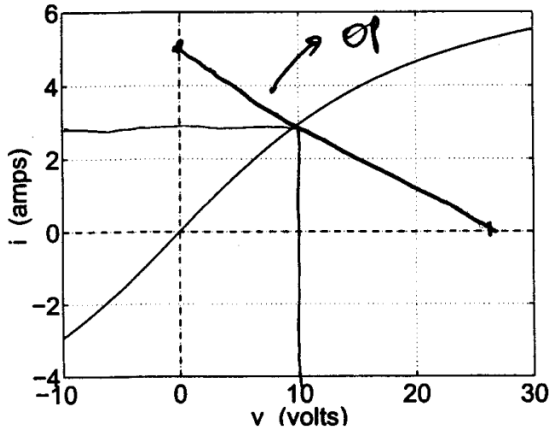
$V_a(V_X, I_Y) =$ $I_y \frac{R_1 R_2}{R_1 + R_2} + V_x \frac{R_2}{R_1 + R_2}$

6. [16 pts] The resistive network shown below is connected to a SISTor B. The SISTor is a nonlinear device with *i* - *v* characteristic shown below. Find the current i drawn by the SISTor and the voltage v across the SISTor.

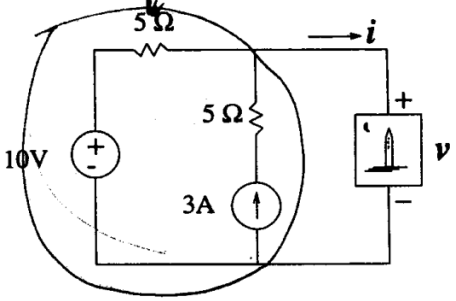




i - v curve for SISTor B.

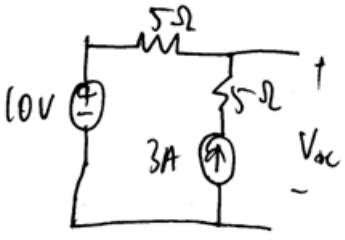


find eq. ckts



find R_{th} ⇒ short all indep sources

$R_{eq} = R_{th} = 5\,\Omega$



$3A = \frac{V_{oc} - 10}{5} \Rightarrow V_{oc} = 25V$

$-V_{th} + IR_{th} + V = 0$

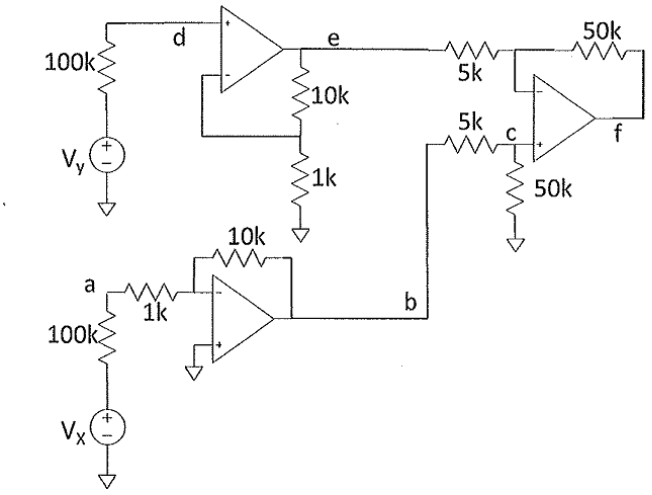
$V_{th} = IR_{th} + V$

① $I = 0 \Rightarrow V = V_{th} = 25V$

② $V = 0 \Rightarrow I = 5A$

$i =$ 3A	$v =$ 10 V

7. [12 pts] In the circuit below, find the gain from V_x to a, from a to b, from b to c, and so on. Assume that the operational amplifiers are ideal.



Gain from V_X to a ($=V_a/V_X$)	1/101
Gain from V_a to V_b ($=V_b/V_a$)	-10
Gain from V_b to V_c ($=V_c/V_b$)	10/11
Gain from V_y to V_d ($=V_d/V_y$)	1
Gain from V_d to V_e ($=V_e/V_d$)	11
Gain from (V_b,V_e) to V_f ($= V_f/(V_b-V_e)$)	10