Name: _____

Discussion Time: _____

# EE 42

# Midterm 1

# February 26, 2004

**PLEASE WRITE YOUR NAME ON EACH ATTACHED PAGE**

**PLEASE SHOW YOUR WORK TO RECEIVE PARTIAL CREDIT**

Problem 1: 15 Points Possible _____

Problem 2: 15 Points Possible _____

Problem 3: 20 Points Possible _____

Problem 4: 15 Points Possible _____

Problem 5: 20 Points Possible _____

Problem 6: 15 Points Possible _____

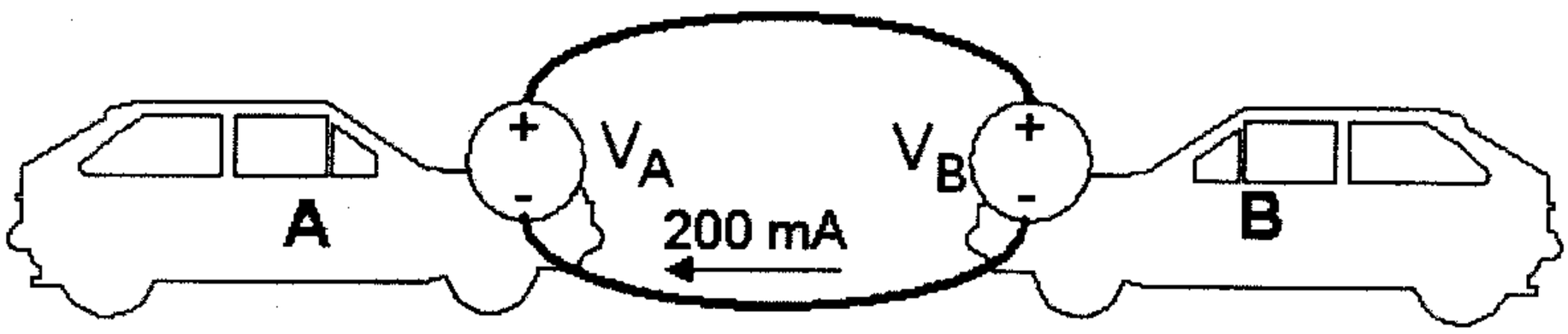
TOTAL: 100 Points Possible _____

**Name:** _____

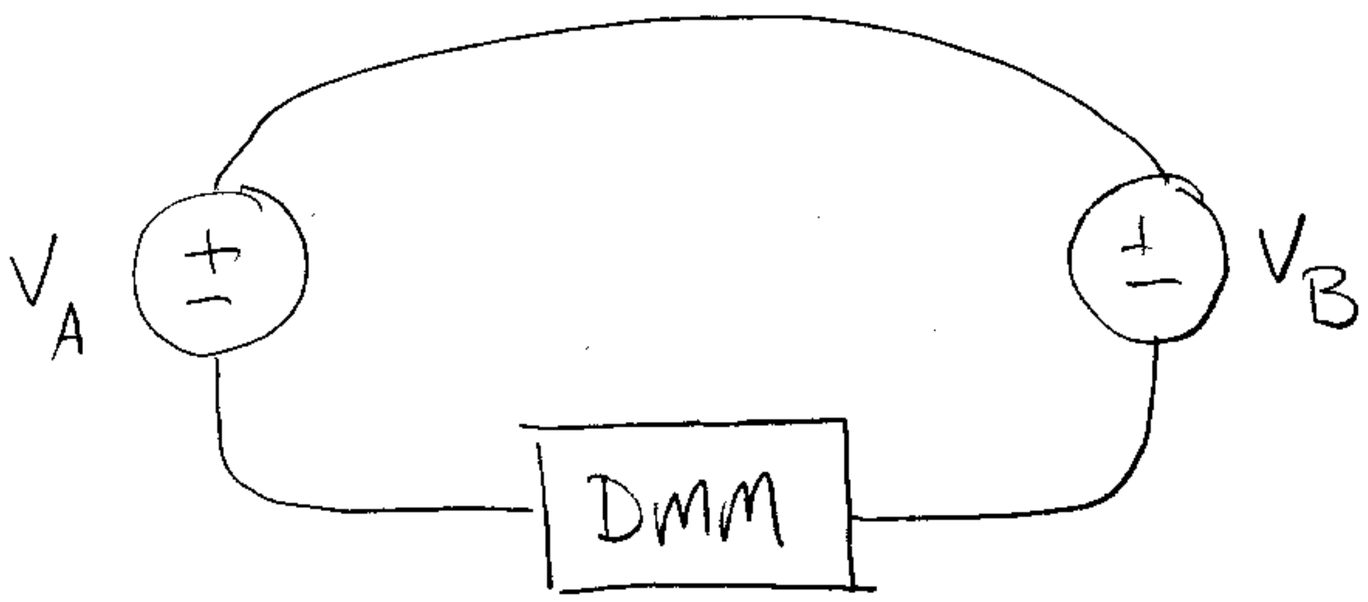
Problem 1: 15 Points Possible

Prof. Ross's lovely blue Honda Civic has a dead battery (again). A passerby offers to recharge her battery using his car battery. Unfortunately, he is one of the thousands of people in the Bay area driving an identical Honda Civic, and once the cars are hooked up, Prof. Ross cannot tell which car is hers!

Luckily, she carries a DMM wherever she goes, and determines that a 200 mA current is flowing as shown between the batteries. (We assume that both batteries have positive voltage ($V_A$ and $V_B > 0$) and that there is some resistance in the cable so that KVL is not violated.)




a) Draw a circuit diagram showing how the DMM is attached to measure current. (You don't need to draw the cars, just the circuit.)




b) Which car belongs to Prof. Ross (which battery is absorbing positive power)? Justify your answer.

Car B.

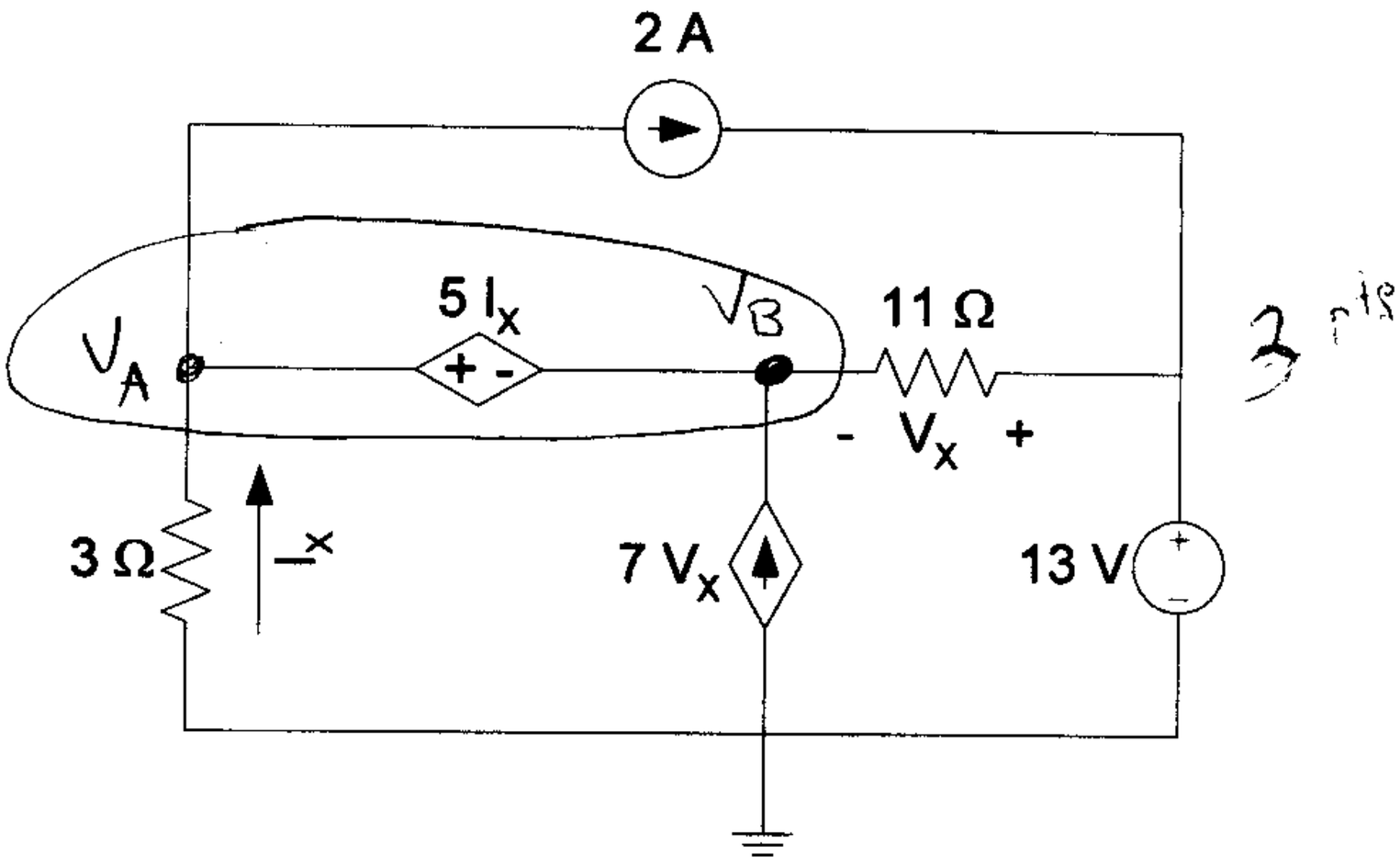
The voltage source on car B has positive current flowing over a positive voltage drop.

power absorbed = (voltage)(current over voltage drop)
> 0 for car B.

**Name:** _____

Problem 2: 15 Points Possible

Perform nodal analysis on the circuit below.
Write down all the necessary equations, but do not solve them.




2 pts

Supernode KCL: $2A - I_x - 7V_x + \frac{V_B - 13}{11} = 0$

Supernode inside: $V_A - V_B = 5I_x$

8 pts

What's $I_x$: $I_x = -\frac{V_A}{3}$

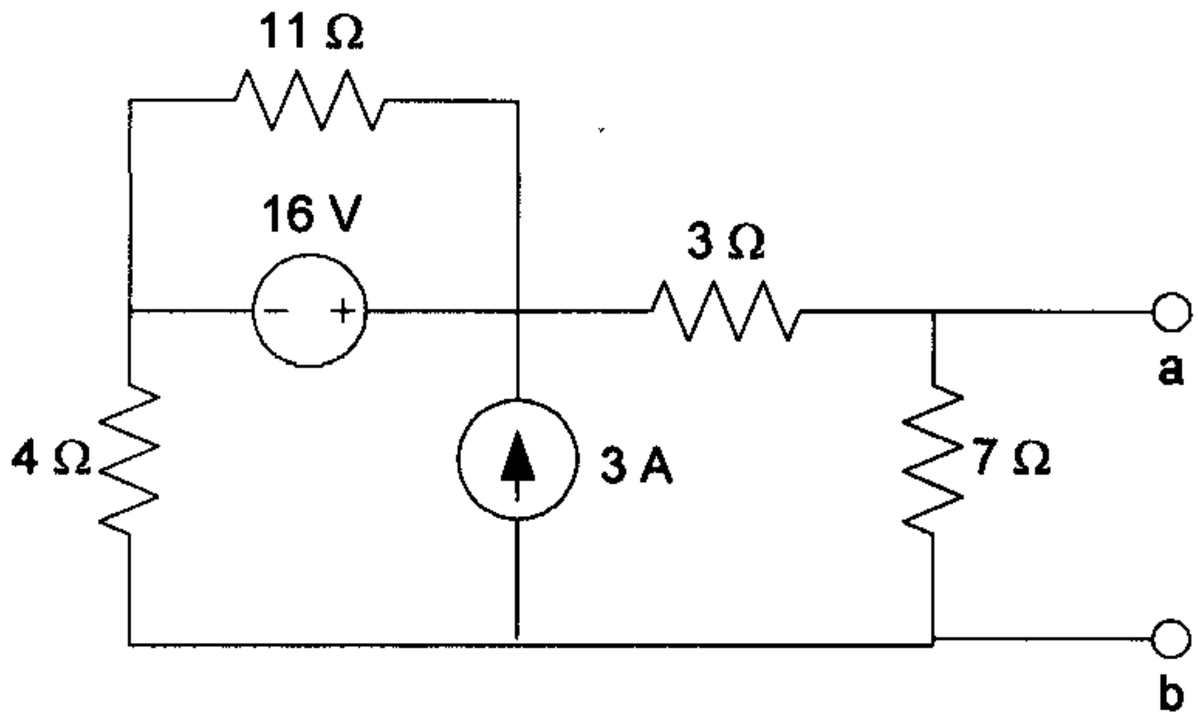
What's $V_x$: $V_x = 13 - V_B$

**Name:** _____

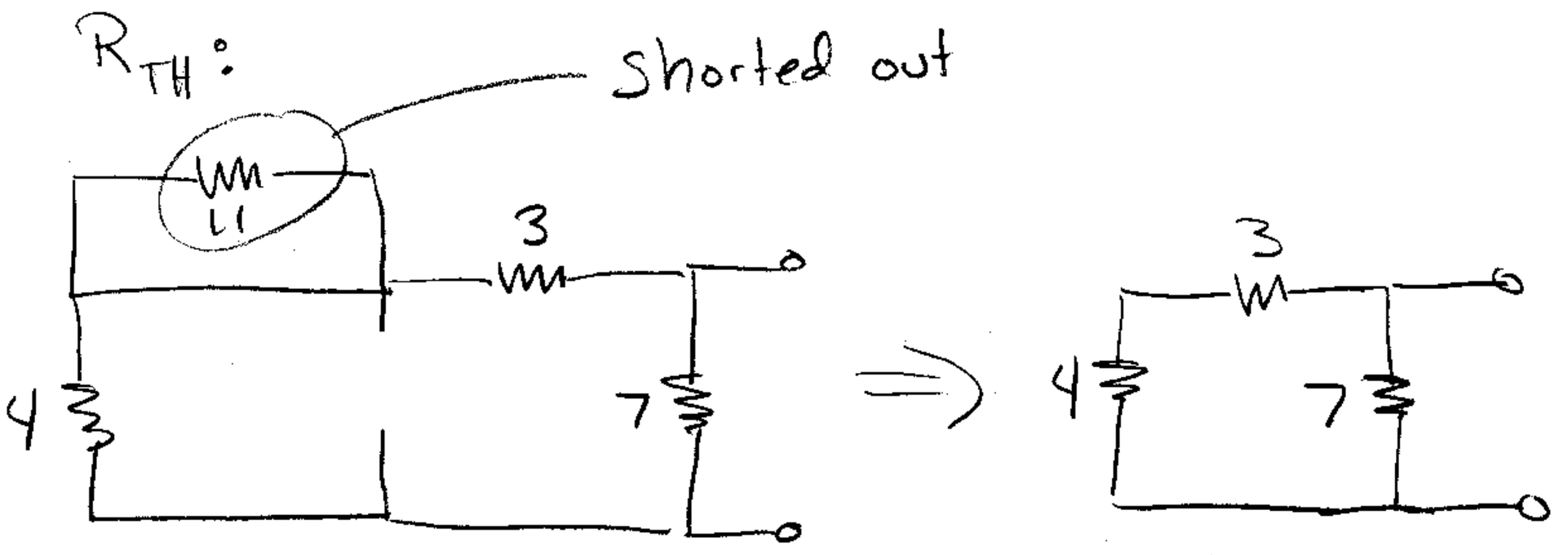
Problem 3: 20 Points Possible

a) Find $V_{TH}$, $R_{TH}$, $I_N$, and $R_N$ for the following circuit.

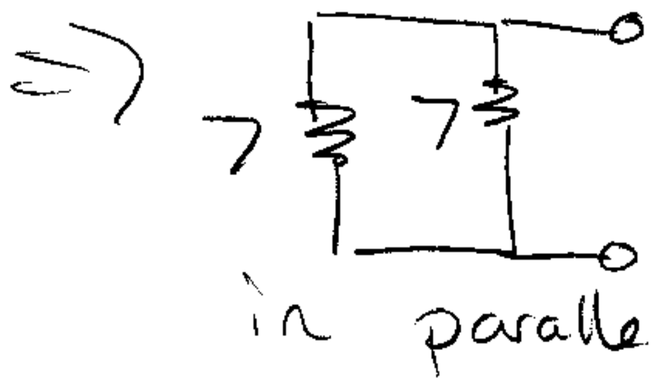
b) Sketch the I-V graph for the circuit.



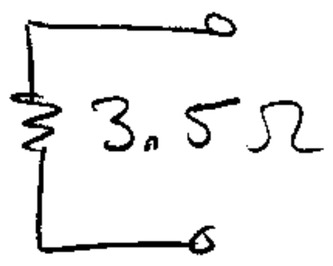

$R_{TH}$:




4 + 3 in series (not 7 if something is attached



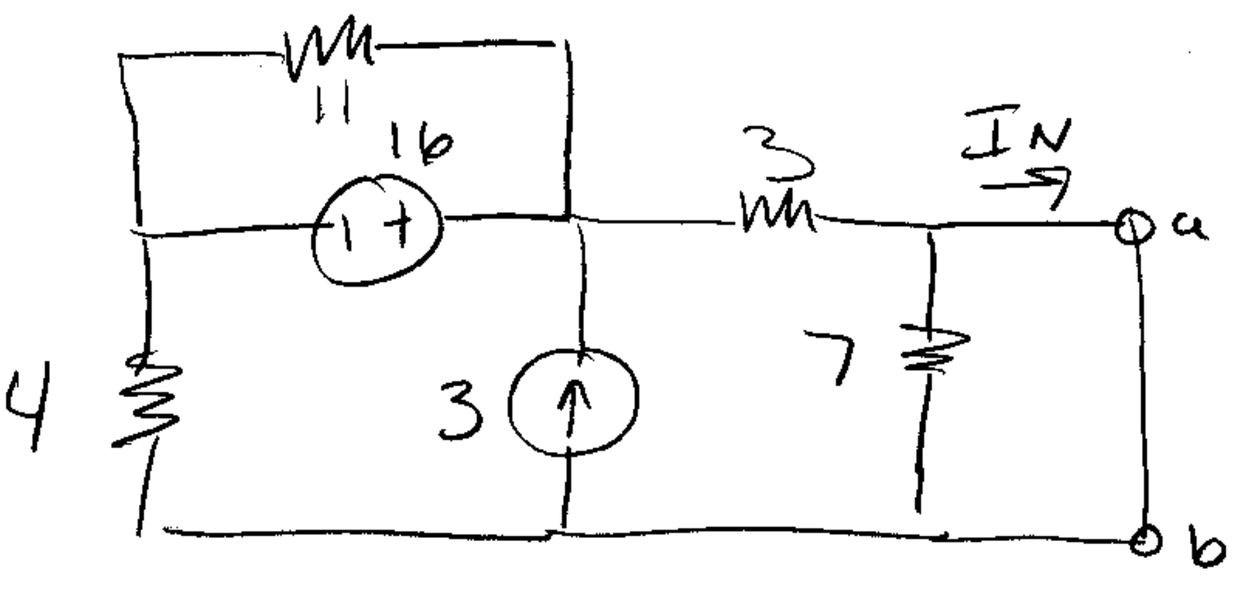

in parallel




$R_{TH} = 3.5\,\Omega$

$R_N = 3.5\,\Omega$

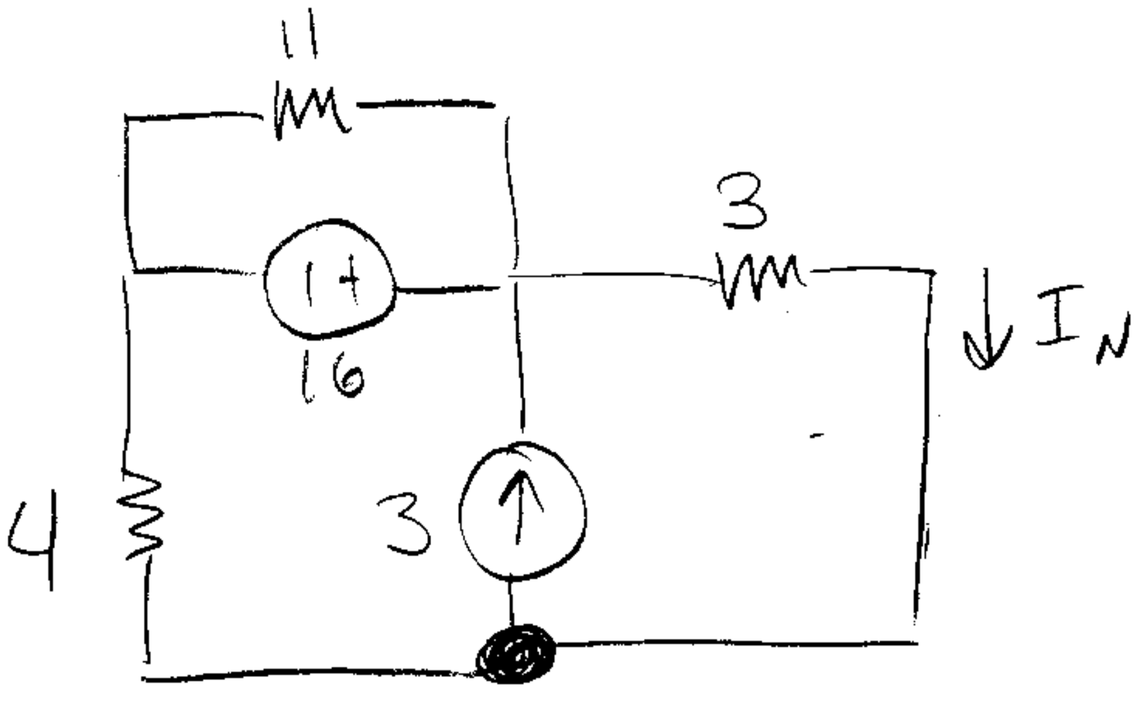
$I_N$:




7 Ω is shorted out

**Name:** _____

**Problem 3 Workspace**



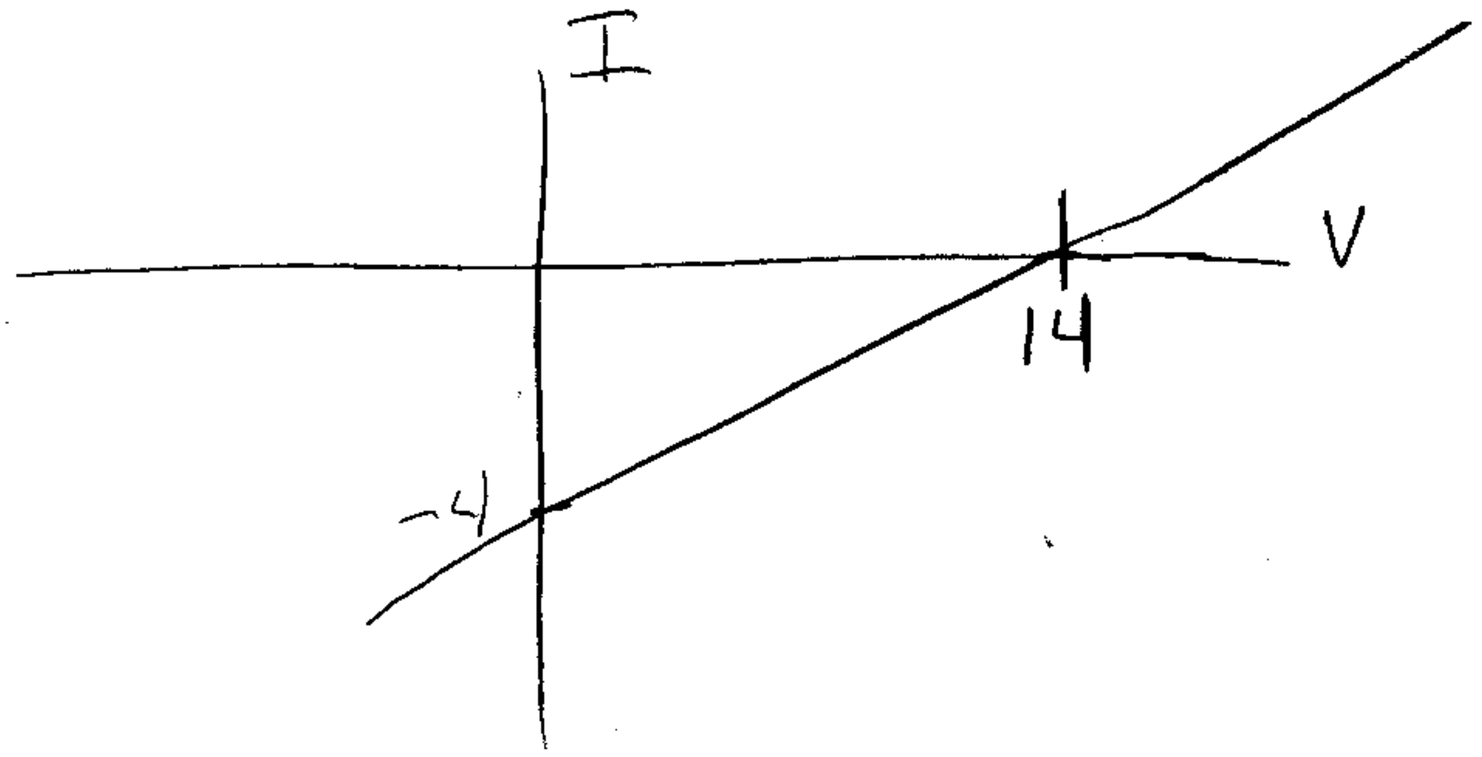

$I_N - 3$ ← By KCL

KVL: $3I_N + 4(I_N - 3) - 16 = 0$

$7I_N = 28$

$$I_N = 4\ A$$

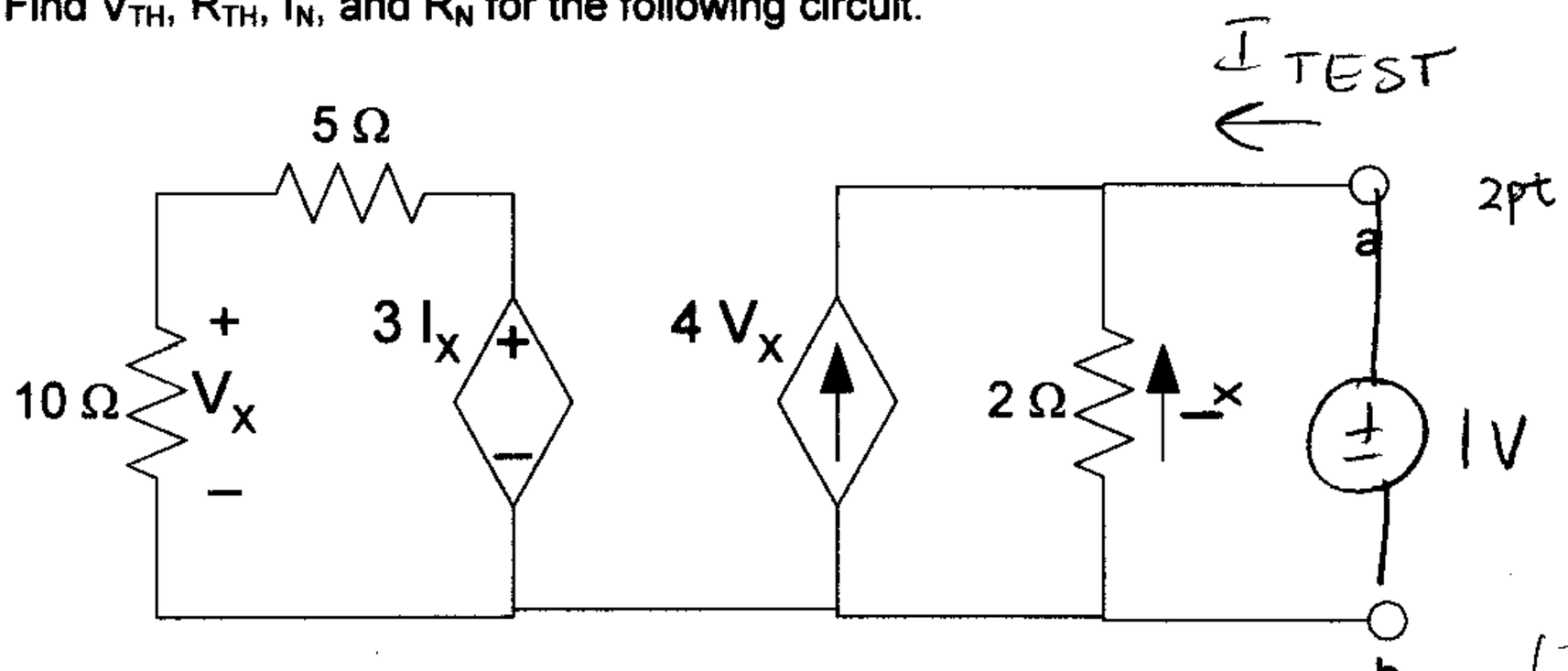
$$V_{TH} = R_N I_N = 14\ V$$



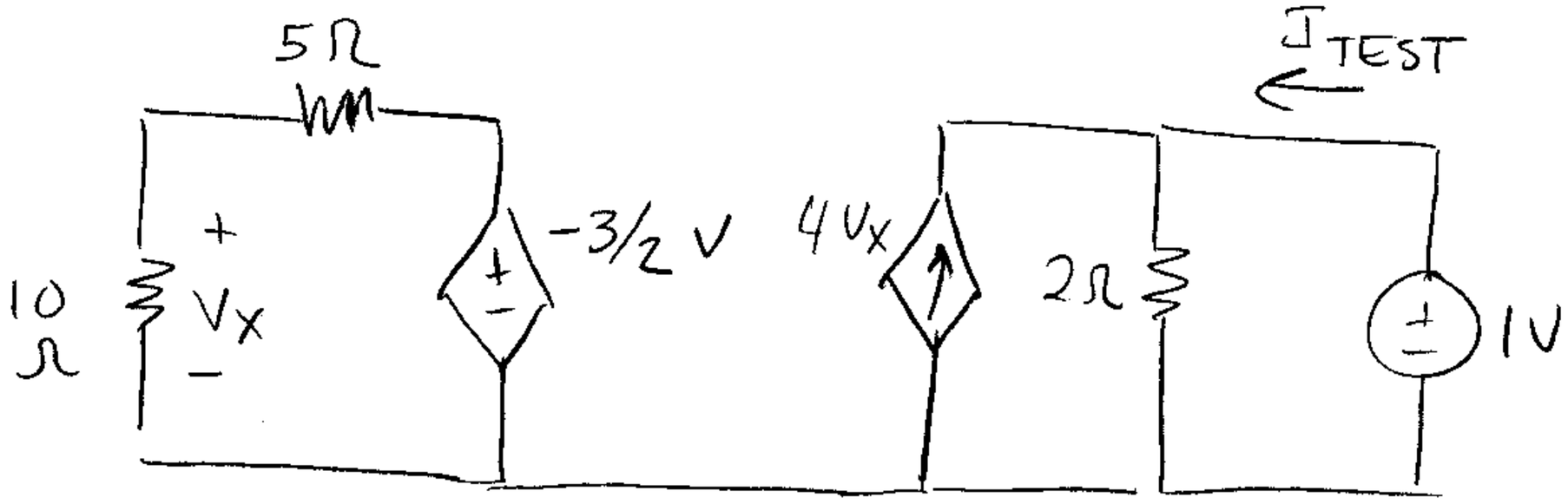
**Name:** _____

Problem 4: 15 Points Possible

Find $V_{TH}$, $R_{TH}$, $I_N$, and $R_N$ for the following circuit.




$I_x = -\frac{1V}{2\Omega}$ (Ohm's law) 2pt



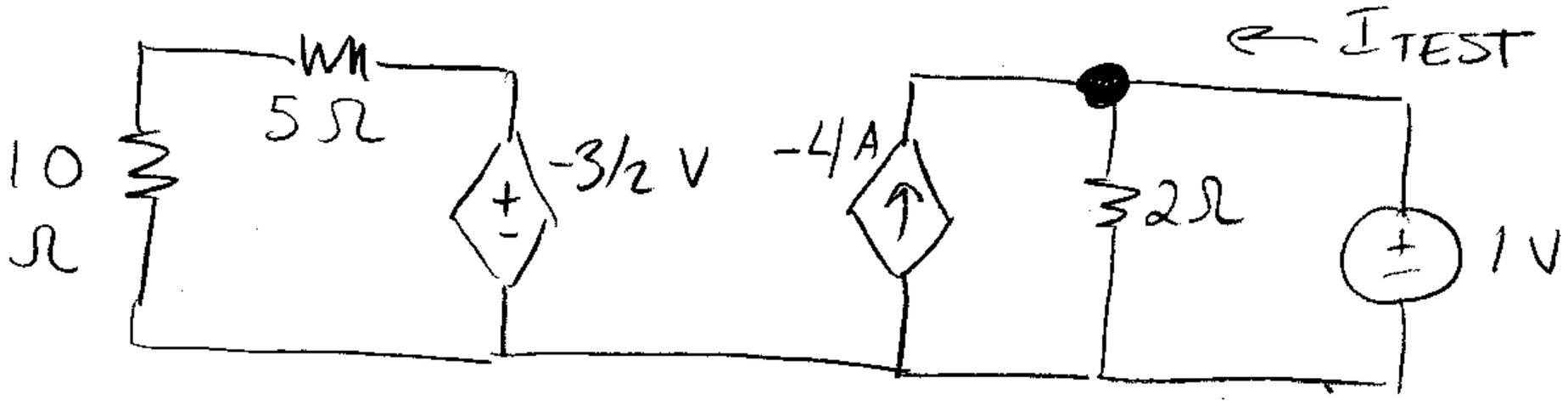

By voltage division (10Ω + 5Ω in series)

$V_x = (-3/2\,V)\left(\frac{10\Omega}{10\Omega + 5\Omega}\right) = -1\,V$ 2pt

$V_{TH} = 0\,V$ 2pt

$I_N = 0\,A$ 2pt

(no indep sources!)




By KCL, $-I_{TEST} - -4A + \frac{1V}{2\Omega} = 0$

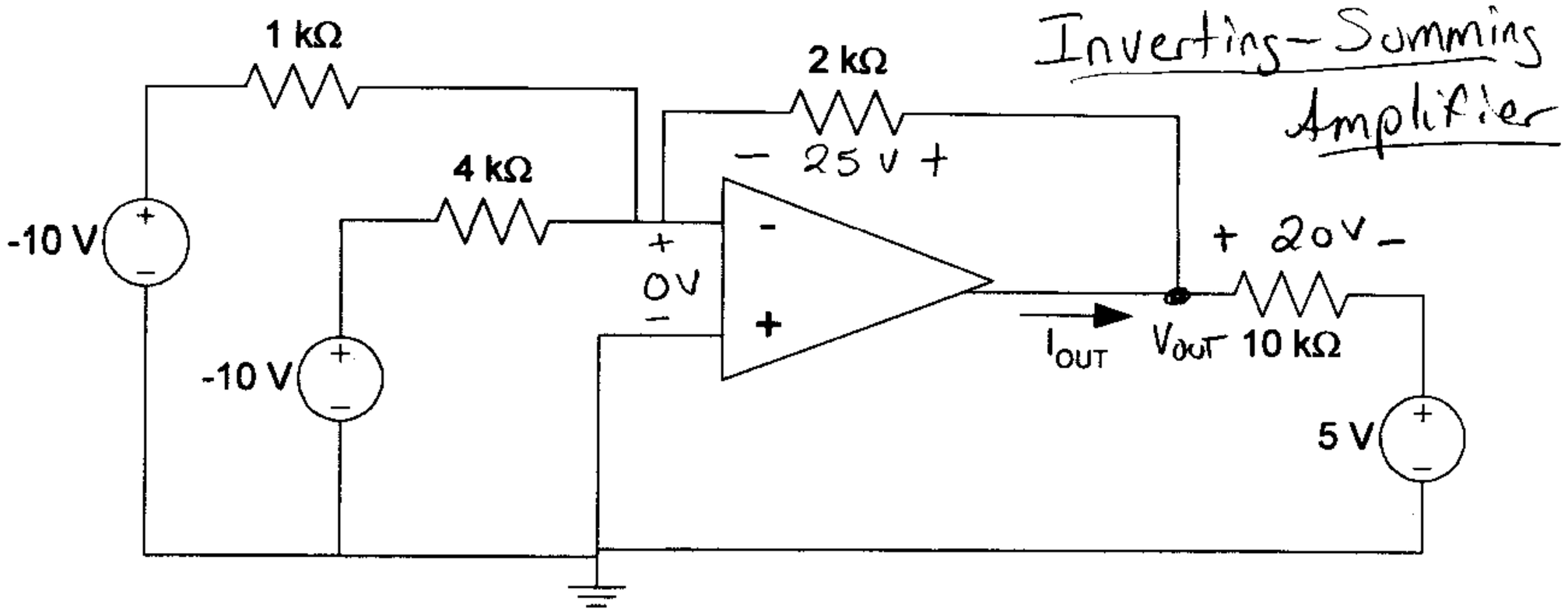
$I_{TEST} = 4.5\,A$ 2pt

$R_{TH} = R_N = \frac{1V}{4.5A} = 2/9\,\Omega$ 2pt 1pt

**Name:** _____

Problem 5: 20 Points Possible

Find $I_{OUT}$. (Use our usual ideal op-amp model which ignores the rails.)




$$V_{OUT} = -\left(\frac{2K\Omega}{4K\Omega}\right)(-10\,V) - \left(\frac{2K\Omega}{1K\Omega}\right)(-10\,V) = 25\,V$$

So 10Ω resistor carries 25 V − 5 V = 20 V as shown.

Since 0 V drop over op-amp inputs, left side of 2K resistor is at ground. Right side is at $V_{OUT}$. Hence, 25 V over 2K resistor as shown.

KCL @ output:

$$-I_{OUT} + \frac{25\,V}{2K\Omega} + \frac{20\,V}{10K\Omega} = 0$$

$$I_{OUT} = 14.5\,mA$$

**Name:** _____

Problem 6: 15 Points Possible

**For this question, show your work for maximum credit.**

Suppose an op-amp with

A = 10 (very weak!)
$R_i = \infty\ \Omega$
$R_O = 0\ \Omega$
Upper rail = 5 V
Lower rail = 0 V

is used to make a comparator.

When the input to the comparator is $\mathbf{V_{IN}(t) = 5\ e^{-1000\ t}}$ V,
the output $V_{OUT}(t)$ begins its descent from 5 V to 0 V at precisely **1 ms**.
(So at 1 ms, the comparator enters the linear region of operation).

**What is the comparator threshold voltage, $V_{THR}$?**

$V_{OUT}(t) = 5V$ (in linear region) when $t = 1ms$

4 pts 4 pts

$V_{OUT}(t) = A(V_+ - V_-) = 10(V_{IN}(t) - V_{THR})$

$= 10(5e^{-1000\,t} - V_{THR})$

$5\ V = 10(5e^{-1000(1ms)} - V_{THR})$ 3 pts

$V_{THR} = 5e^{-1} - 0.5 = 1.34\ V$ 4 pts