Name: Solutions

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# EE 40

# Midterm 1

# September 26, 2002

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

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

Problem 1: 10 Points Possible _____

Problem 2: 10 Points Possible _____

Problem 3: 20 Points Possible _____

Problem 4: 20 Points Possible _____

Problem 5: 20 Points Possible _____

Problem 6: 20 Points Possible _____

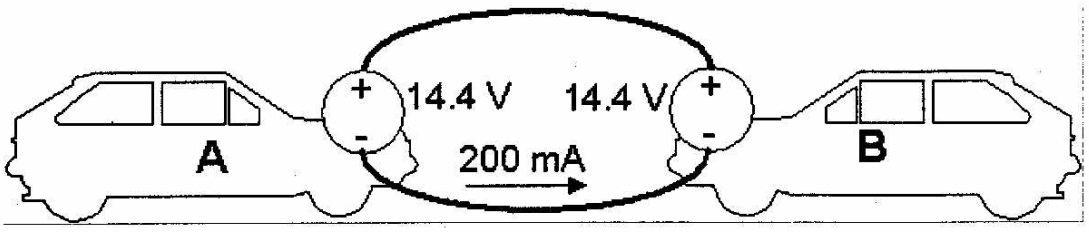
TOTAL: 100 Points Possible _____

**Name:** Solutions

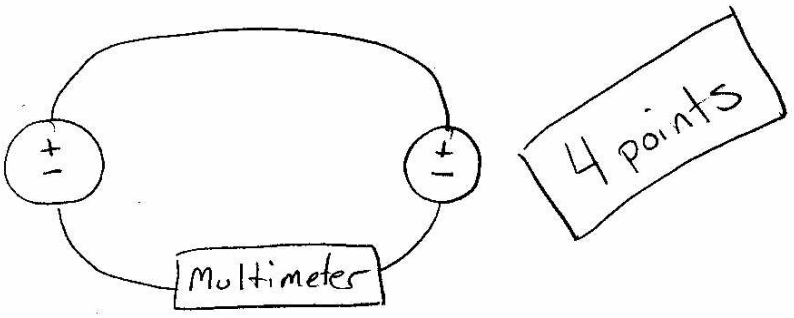
Problem 1: 10 Points Possible

Prof. Ross's lovely blue Honda Civic has a dead battery. 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 digital multimeter wherever she goes, and determines that a 200 mA current is flowing as shown between the 14.4 V batteries.




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




4 Points

b) Which car belongs to Prof. Ross (which battery is being charged)? Justify your answer.

Because positive current goes from + to − thru battery A

or because positive current is associated with battery A voltage

or because power, using our convention, is positive for bat. A

Car A belongs to Prof. Ross

c) How much power is Prof. Ross's battery absorbing?

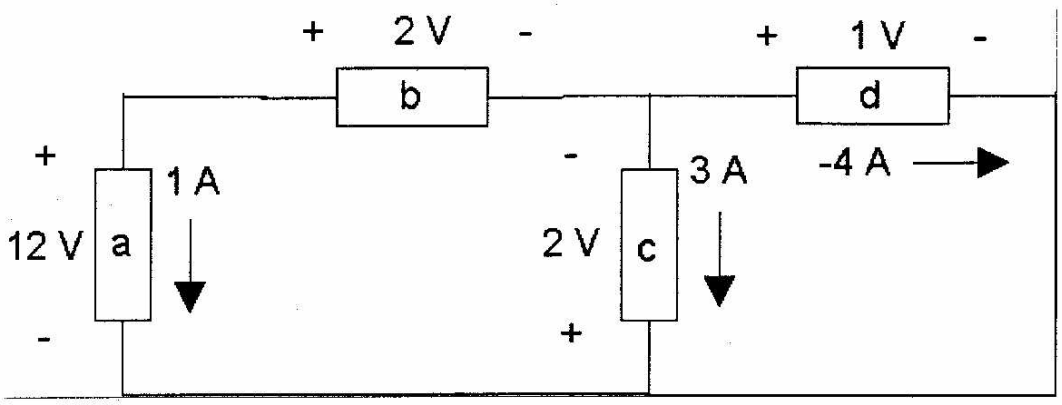
$14.4\ V \times 200 \times 10^{-3}\ A = 2.88\ W$

2 Points

**Name:** Solutions

Problem 2: 10 Points Possible

A certain absent-minded professor does not always proofread her notes and homework carefully, and a student mentions that there is "something wrong" with the following circuit that was assigned in a homework.




Is there something wrong with this circuit? If so, what?

KVL is not satisfied

in left loop

$-12 + 2 - 2 \neq 0$
(a, b, c)

or in right loop

$2 + 1 \neq 0$
(c, d)

or in outer loop

$-12 + 2 + 1 \neq 0$
(a, b, d)

That is very wrong.

10 Points for correct KVL calculation
≈7 Points for correct conclusion but calc incorrect
≈5 Points for wrong statement like KCL not satisfied along with correct conclusion

**Name:** _____

Problem 3: 20 Points Possible

Consider the following truth table for a Boolean function F with inputs A, B, and C:

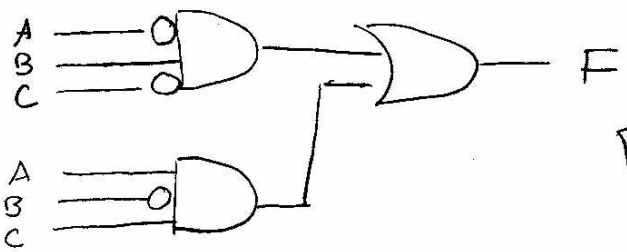
| A | B | C | F |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |

$\bar{A}B\bar{C}$

$A\bar{B}C$

a) Use the "sum of products" method to implement a logic circuit for this function. YOU DO NOT NEED TO SIMPLIFY THE CIRCUIT. You may use three-input gates.

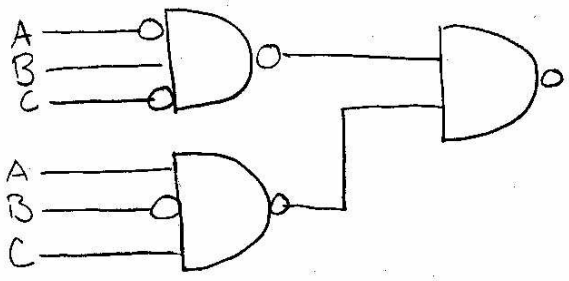
$F = \bar{A}B\bar{C} + A\bar{B}C$




7 points

b) Implement the above circuit using only NAND and NOT (inverter) gates. YOU DO NOT NEED TO SIMPLIFY THE CIRCUIT. You may use three-input gates.

Just replace AND & OR gates with NAND.




4 Points

c) Can every Boolean function be implemented using only two-input NAND gates? Why or why not?

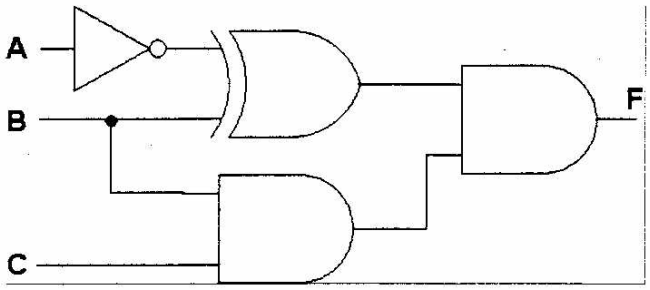
You can write any Boolean function as sum of products, and then 1) Change AND + OR to NAND by De Morgan's Thm
2) Make an inverter out of a NAND gate
3) Make a multi-input NAND out of 2-input NANDs

9 Points
≈ 3 points for each reason

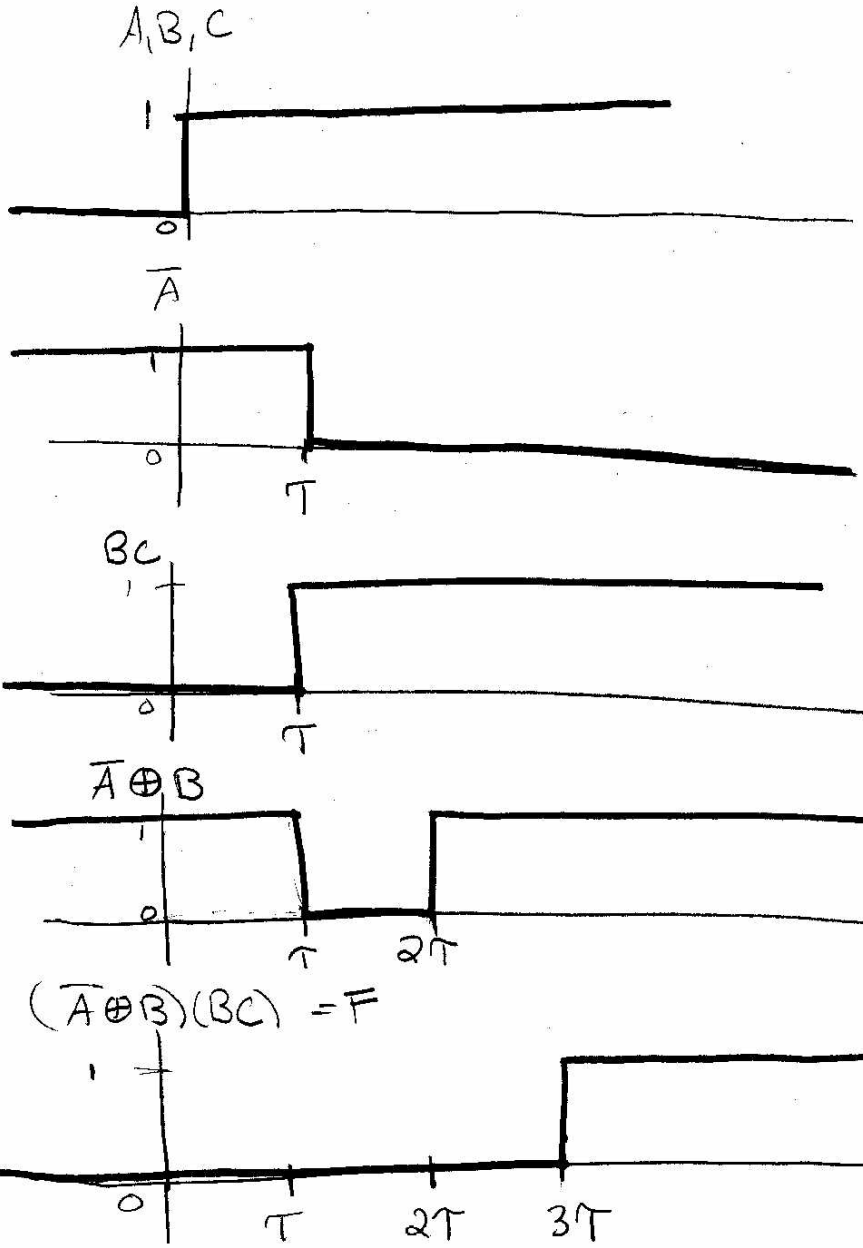
**Name:** _____

Problem 4: 20 Points Possible

Consider the logic circuit below. Assume that inputs A, B, and C have been at logic zero for a long time, and then instantaneously change to logic 1 at time t=0. Assume also that each logic gate has propagation delay $\tau$.




Draw a timing diagram indicating the logic transitions of the output F.

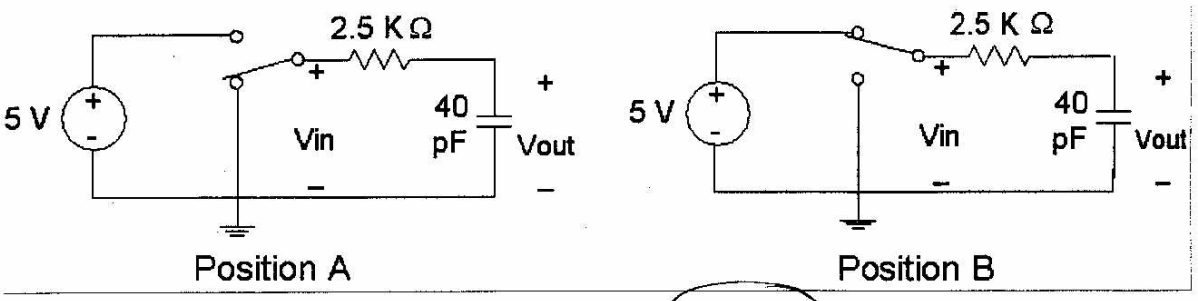



5 points each for the last four diagrams (20 total)

**Name:** _____

Problem 5: 20 Points Possible

Consider the usual RC circuit model for gate delay shown below, with the switch implementing the step changes in Vin.




a) What is Vin when the switch is in Position A? 0V

2 Points — Vin is short-circuited (a wire goes from + to −)

b) What is Vin when the switch is in Position B? 5V

2 Points — Vin is voltage over source (+ node of src at +Vin, − node of src at −Vin)

c) Suppose the switch is in Position A for a long time, then instantaneously switches to Position B at time t=0. Write the equation for Vout(t).

5 points

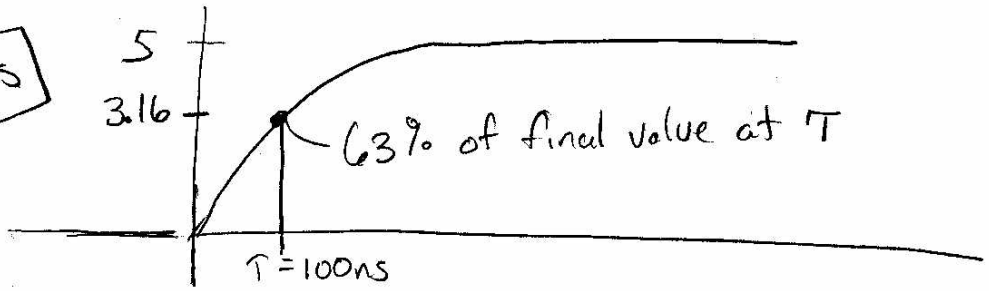
$V_{in} = V_f = 5V \quad V_{out}(t=0) = 0V \quad T = RC = 100ns$

$V_{out}(t) = V_{in} + (V_{out}(t=0) - V_{in})\, e^{-t/T}$

$= 5 - 5e^{-t/100ns}\ V$ for $t \geq 0$, 0 for $t < 0$

d) Graph Vout(t), indicating the value of Vout after one time constant.

5 points




e) Suppose I know that the voltage source will blow a fuse if the current through it reaches 1 A in magnitude. Will the voltage source blow a fuse in this case?

6 Points

$i = \frac{V_{out} - V_{in}}{2.5K\Omega} = \frac{5e^{-t/100ns}}{2.5K\Omega} = 2\times10^{-3} e^{-t/100ns} A$

$2\times10^{-3}$ A is max value — No, fuse is not blown.

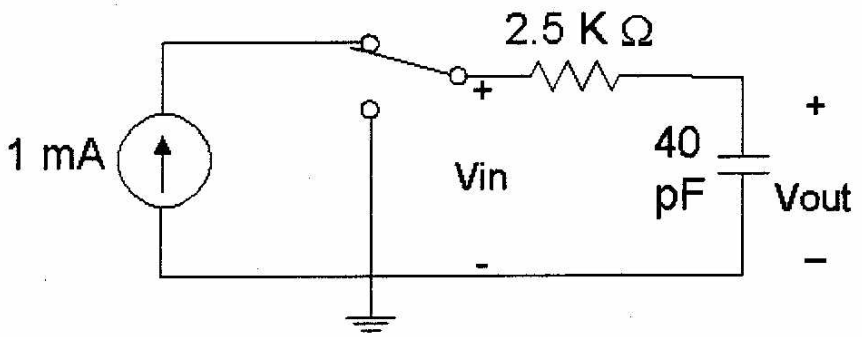
**Name:** _____

Problem 6: 20 Points Possible

Refer back to Problem 5, where the circuit instantaneously switches from Position A to Position B at t=0 (after being in Position A for a long time).

Suppose that at t = 100 ns, a magician comes along and instantaneously turns the voltage source into a 1 mA current source.

So the circuit is in Position A for t < 0, moves to Position B for 0 ≤ t < 100 ns, and switches to the circuit below at t = 100 ns:




Ha Ha! I've really confused them now!

14 Points Various Partial Credit

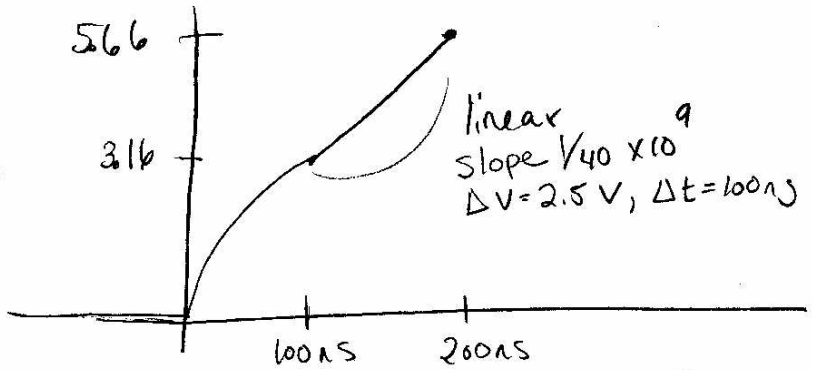
a) Graph Vout(t), indicating the value of Vout at 100 ns and 200 ns.

$i_C = C\frac{dv}{dt}$

$1mA = 40pF\frac{dv}{dt}$

$\frac{dv}{dt} = \frac{1\times10^{-3}}{40\times10^{-12}} = 1/40\times10^{9}$

for $t > 100$ ns




$\Delta V = \frac{dv}{dt}\Delta t$

$\Delta V = (1/40\times10^{9})(100\cdot10^{-9}) = 2.5V$ (over period 100ns to 200ns)

b) Write the equation for Vout(t) for t>0. If your equation has multiple parts, be sure to specify when each part is valid.

$$V_{out}(t) = \begin{cases} 5 - 5e^{-t/100\,ns} & 0 \le t \le 100ns \\ 3.16 + 1/40\times10^{9}(t - 100ns) & t > 100\,ns \end{cases}$$

6 Points
2 for linear function
2 for right init value
2 for t-100ns offset