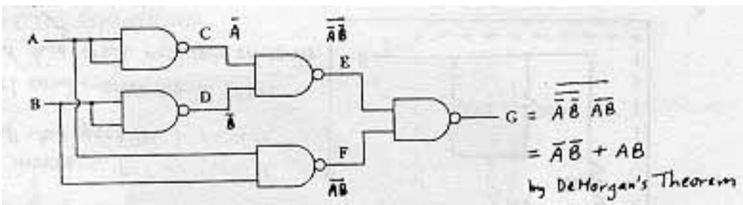
EECS40, Spring 2000
Midterm 1 solutions
Prof King

Problem #1



a)

A	B	G
0	0	1
0	1	0
1	0	0
1	1	1

b)

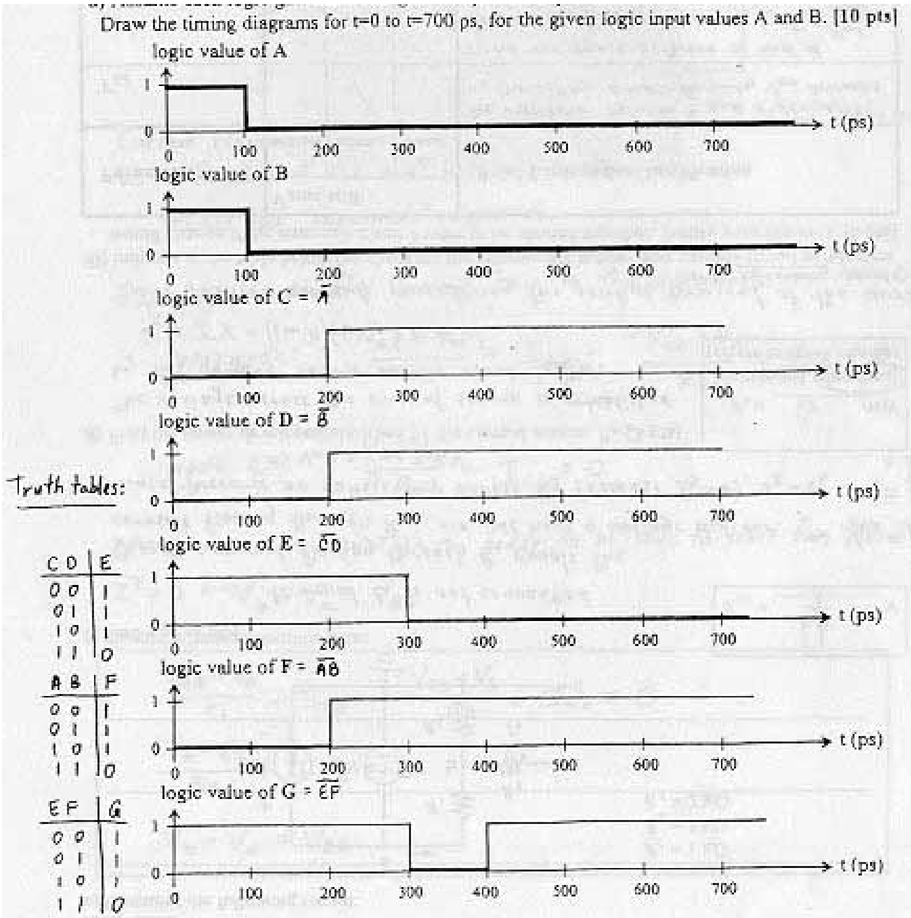
G = (not A)(not B) + AB

c)

3 unit gate delays

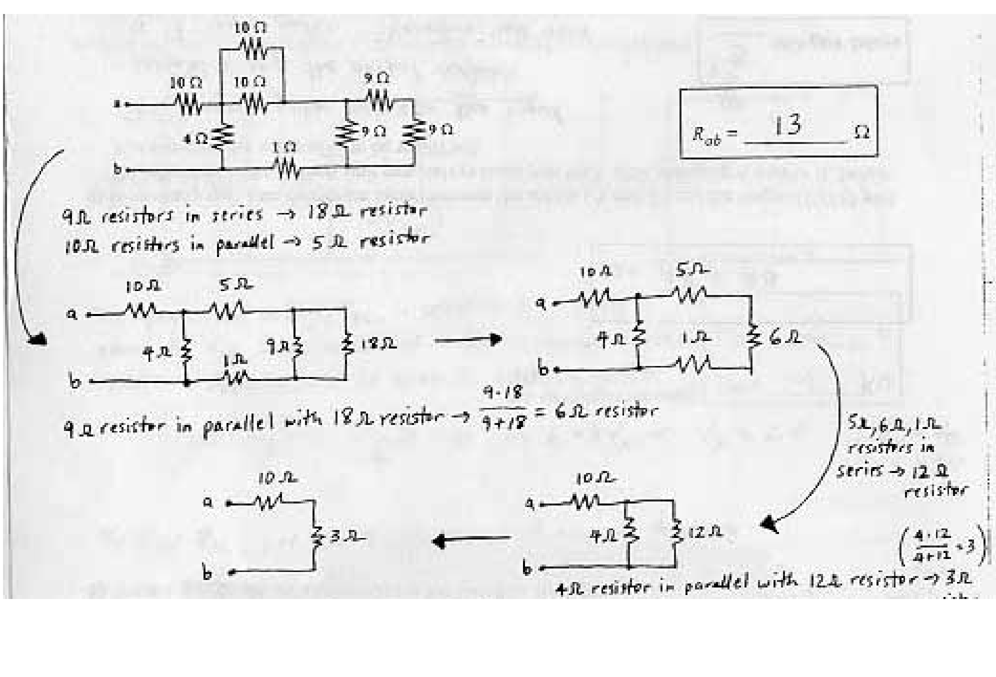
The longest path between the input variables and the output variable is 3 logic gates. Therefore, we need to wait for a period of 3 unit gate delays after an input variable is changed, before we can trust the value of G to be valid.

d)



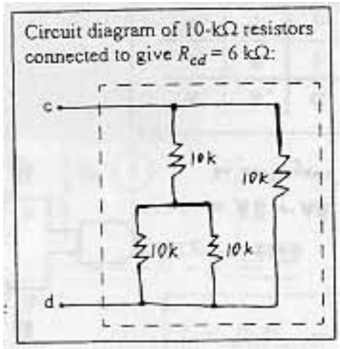
Problem #2
a)

Rab = 13 ohms



d)

b)



* To achieve an equivalent resistance lower than the individual resistors, we should connect resistors in parallel
* But the parallel combination of 2 10 kohm resistors is 5 kohm -- too low!
=> need to increase the resistance of one of the parallel branches
* Try parallel combination of a 10 kohm resistor and 2 10 kohm resistors in series:
(20*10)/(20+10) = 6.7 kohm -- too high!
* Try increasing the resistance of one parallel branch by only 5 kohm (10 kohm || 10 kohm) instead of 10 kohm
(15*10)/(15+10) = 6 kohm!

c)

(ground is placed at the bottom of the diagram)

i)

Vcd = 4 V

I3 = 0 since terminal c is not connected. Thus the current flowing through R1 equals the current flowing through R2, i.e. we have a voltage divider.
=> Vbd = (R2/(R1+R2))*6 = (2/(1+2))*6 = 4 V
Since there is no voltage drop across R3 (because I3 = 0), Vc = Vb
=>Vcd = Vbd = 4 V

ii)

(underscore denotes subscript for uppercase variables)

P_I = 6 mW absorbed

The voltage across the current source is established by the voltage source and is equal to 6 V.
P_I = IV = (1 mA)(6 V) = 6 mW
Since positive current is entering the positive terminal of the current source it is absorbing power

iii)

Parameter	value will:	Brief Explanation
Vbd	decrease	The resistance between b and d decreases; by the voltage-divider formula, Vbd decreases

I1	increase	Total resistance between a and d decreases; Vad remains 6V; I1 = Vad/Rad
Power developed by voltage source	increase	Since I1 increases, the current supplied by the voltage source increases

iv)

I3 = 1.5 mA

Equivalent resistance between terminals a and d is
R1 + R2||R3 = 1 + (2*2)/(2+2) = 2 kohm
=> I1 = (6 V)/(2 kohm) = 3 mA
Using current-divider formula, I3 = (2/(2+2))*(3 mA) = 1.5 mA

Problem #3

(underscore denotes subscript for uppercase variables)

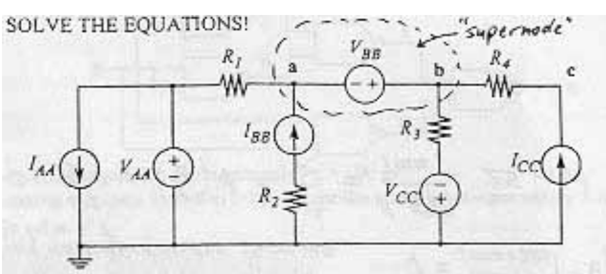
a)

nodal equations:
(V_AA - Va)/R1 + I_BB - I_CC + (Vb - Va)/R3 = 0
(Va - Vb)/R3 - (V_BB + Vb)/R4 + (Vc - Vb)/R5 = 0
I_CC + (Vb - Vc)/R5 - Vc/R6 = 0

Apply Kirchhoff's Current Law to nodes a, b, c:
(sum of currents entering a node = 0)
get 3 independent equations for 3 unknowns (Va, Vb, Vc) => can solve to find unknowns

b)

nodal equations:
(V_AA - Va)/R1 + I_BB - (V_CC + Vb)/R3 + I_CC = 0
(Vb - Vc)/R4 + I_CC = 0
Vb - Va = V_BB



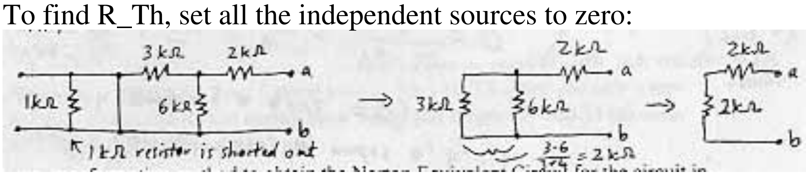
Current flowing through the voltage source V_BB cannot be expressed as a function of the node voltages Va and Vb
=> use the "supernode" approach
Applying Kirchhoff's Current Law to the supernode and node c:
supernode: (V_AA - Va)/R1 + I_BB + (-V_CC - Vb)/R3 + I_CC = 0
node c: (Vb - Vc)/R4 + I_CC = 0
Need one more equation in order to be able to solve for the 3 unknowns:
Vb - Va = V_BB

Problem #4

a)

V_Th = 2 V
R_Th = 4 kohm

(x is the node between the 3 kohm and 2 kohm resistors)
The open-circuit voltage, Voc, is equal to Vab, which is equal to Vxb since no current is flowing through the 2 kohm resistor. Applying KCL to node x (defining node b as the reference node)
-> (5-Vx)/3 + (-4-Vx)/6 = 0
=> 6 = 3 Vx => Vx = 2 V therefore Voc = V_Th = 2 V
To find R_Th, set all the independent sources to zero:

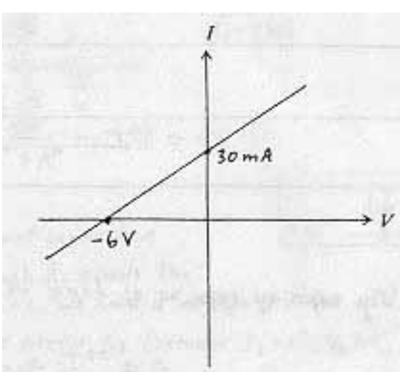


b)

I_N = 0.5 mA
R_N = 4 kohm

R_N = R_Th = 4 kohm
I_N = V_Th/R_Th = (2 V)/(4 kohm) = 0.5 mA

c)

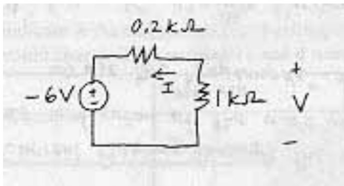


When I = 0, V = -6V
When V = 0 (i.e. terminals a and b shorted together), I = (0 - (-6 V))/200 => I = 30 mA

d)

P1k = 25 mW

nodal equations:(V_AA - Va)/R1 + I_BB - (V_CC + Vb)/R3 + I_CC = 0(Vb - Vc)/R4 + I_CC = 0Vb - Va = V_BB



Using voltage-divider formula,
V = (1000/(1000+200))*(-6) = -5 V
P = IV = (V/R)*V = V^2/R = ((-5)^2)/1000 = 25 mW

P1k = 25 mW