CS 150, Spring 1992
Midterm #1 Solutions
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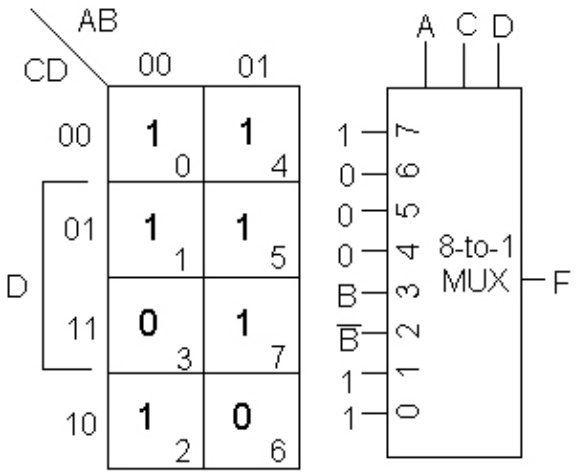
Problem #1a

T = tape properly threaded, M = manual mode (automatic = ~M), E = end-of-tape present, S = start pressed, C = 'tape on' from computer, R = run tape drive.
R = T~E(MS + ~MC)

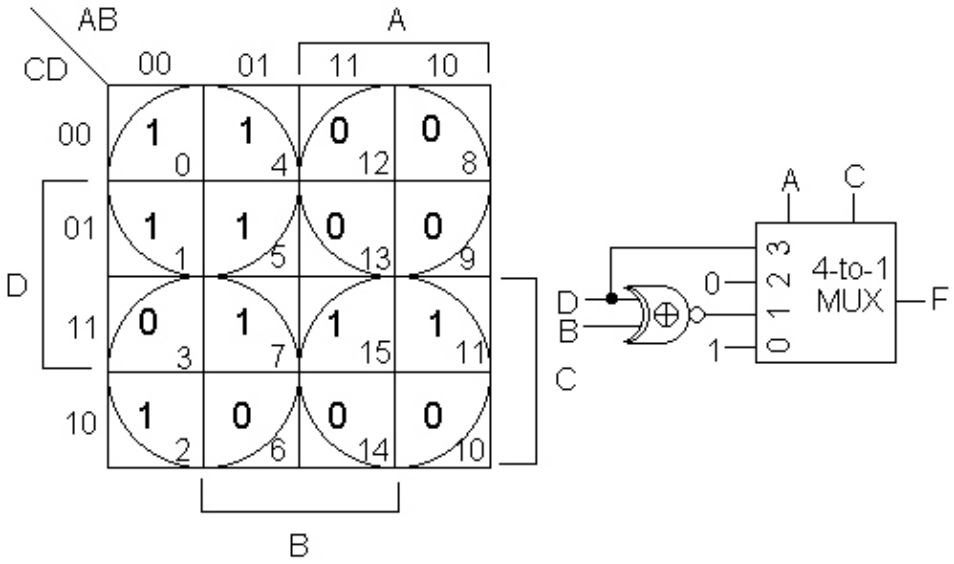
Problem #1b

(i) Maxterm representation: F = [Product/PI] M(6,7,9,10,13,14,15)
(ii) Minimum S-of-P form: ~F = BC + A~CD + AC~D
(iii) Minimum P-of-S form: F = (~B + ~C)(~A + C + ~D)(~A + ~C + D)

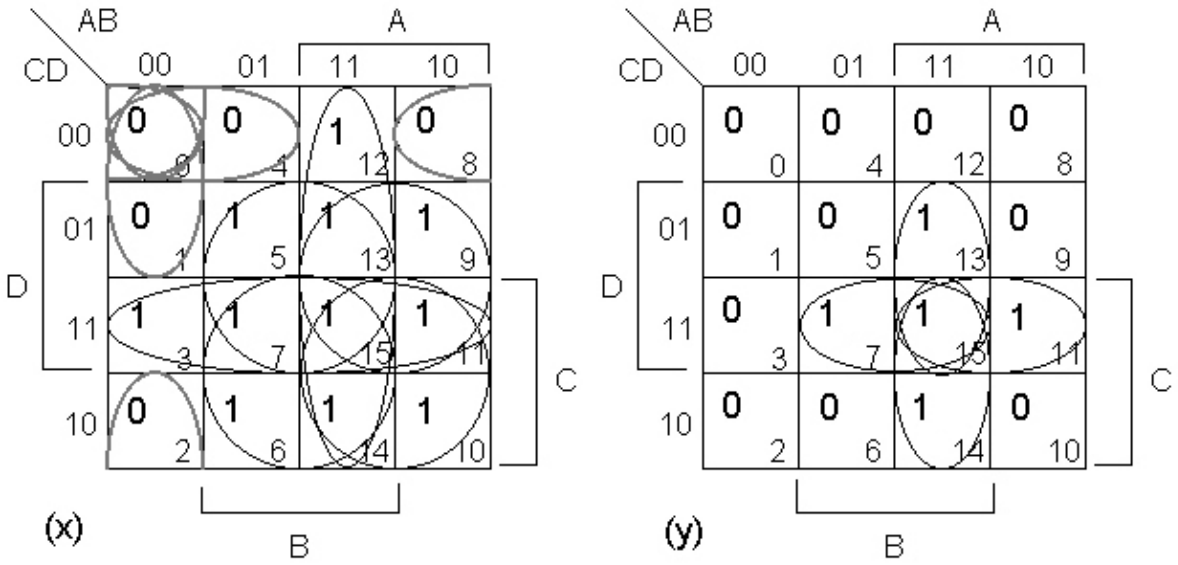
Problem #2a



Problem #2b

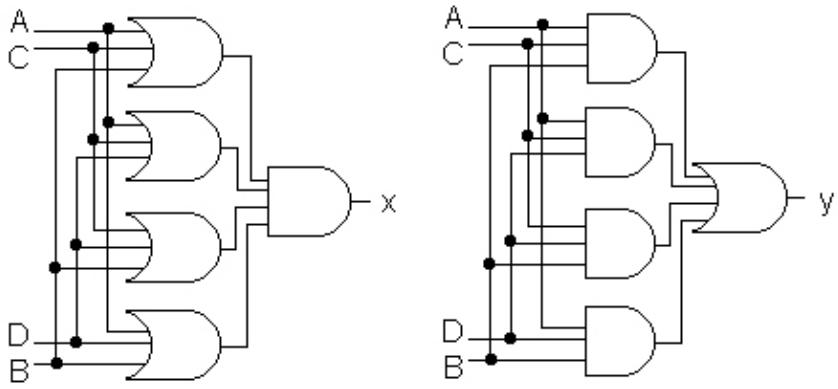


Problem #3a



Problem #3b

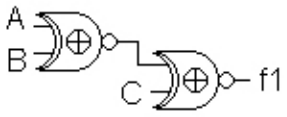
Better to realize ~x and then De Morgan (fewer gates):
~x = ~A~B~C + ~A~C~D + ~B~C~D + ~A~B~D
x = (A + B + C)(A + C + D)(B + C + D)(A + B + D)
y = ABC + ACD + BCD + ABD



Problem #4a

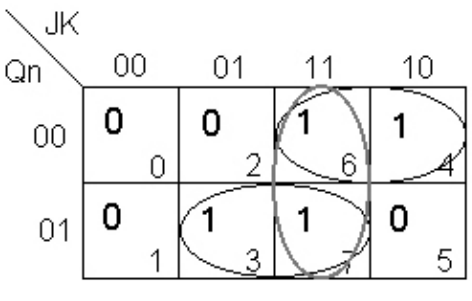
f1 = (A~B + ~AB) = A (+) B
f2 = AB + f1C = AB + C(A~B + ~AB) = AB + C(A (+) B)
f3 = f1~C + ~f1C = f1 (+) C = A (+) B (+) C

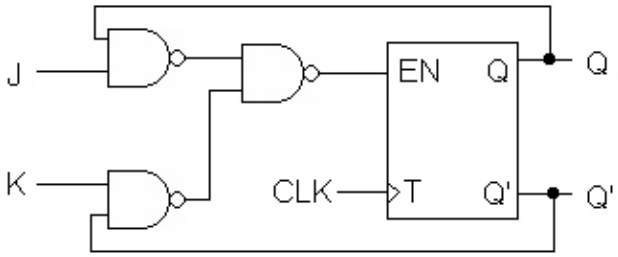
Problem #4b



Problem #5a

Qn	J	K	Qn+1	En
0	0	0	0	0
0	0	1	0	0
0	1	0	1	1
0	1	1	1	1
1	0	0	1	0
1	0	1	0	1
1	1	0	1	0
1	1	1	0	1





Problem #5b

Yes, a hazard does exist in the Q -> ~Q transition, as shown in the K-map above. It will not cause a problem if the clock pulse is wider than two gate delays. It can be removed by adding the implicant shown in grey above, corresponding to the logic gate below.