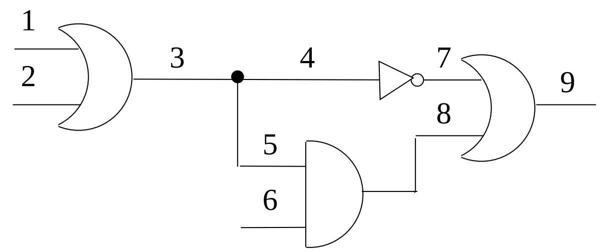
ID2218 Final Exam, May 24, 2010, 60 points

Name:

PN:

1) **(3 points)** Find **all** tests for the stuck-at-0 fault shown below.



2) **(2 points)** A ticket reservation system has 7 days per year downtime. What is its steady-state availability?

3) **(4 points)** A copy machines manufacturer estimates that the reliability of the machines he produces is 73% during the first 3 years of operation.

(a) How many copy machines will need a repair during the first year of operation?

(b) What is the MTTF of the copy machines?

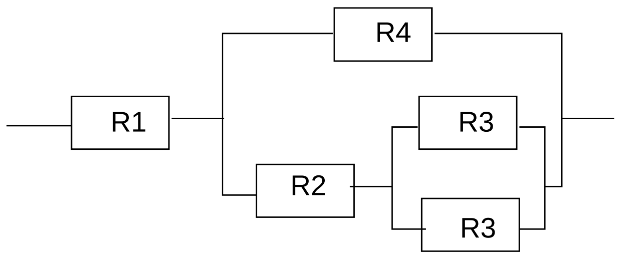
(c) The manufactures guarantees MTTR = 2 days. What is the MTBF of the copy machines?

(d) Suppose that two copy machines work in parallel and the failures are independent. What is the probability of failure during the first year of operation?

4) **(5 points)** You company produces a system which consists of two components, A and B, placed in series. The reliabilities of the components are $R_A = 0.99$ and $R_B = 0.85$. Their cost is approximately the same.

The warranty for this system is 1 year. Your boss decides that too many items are returned for repair during the warranty period. He gives you a task of improving the reliability of the system so that no more than 2% of items are returned for repair during the first year of operation. This should be done by adding no more than two redundant components to the system. Find a reliability block diagram for the system which meets your boss's requirements.

5) **(3 points)** Write an expression for the reliability of the system shown by the reliability block diagram below Assume that R_1, R_2, R_3, R_4 and R_5 are reliabilities on the modules. Do not simplify the expression by opening brackets.



6) Draw a Markov chain for 3-modular redundancy with one spare and the standard majority voter for the cases listed below.

(a) **(5 points)** Do reliability evaluation. Assume that:

- Each of the main modules has the failure rate λ_m. The spare has the failure rate λ_s.
- The spare cannot fail while in the spare mode.
- The voter, switch and disagreement detector units are perfect.
- No repairs are allowed.

(b) **(5 points)** Do availability evaluation. Assume that:

- The modules and the spare have the same failure rate λ. The voter has the failure rate λ_v.
- The spare cannot fail while in the spare mode.
- The switch and disagreement detector units are perfect.
- Repairs are allowed. There are 2 repair teams. The repair rate of each module and the spare is μ.
- When the system fails, it shuts itself down.

(c) **(5 points)** Do safety evaluation. Assume that:

- The modules and the spare have the same failure rate λ.
- The spare cannot fail while in the spare mode.
- The voter and switch are perfect.
- The disagreement detector unit detects the disagreement with the probability C.
- No repairs are allowed.

7) **(2 points)** Suppose that a system was modeled using a Markov chain with 3 states: S_1, S_2 and S_3, and the following set of differential equations (in matrix form) were obtained from this chain:

$$\frac{d}{dt}\begin{bmatrix} P_1(t) \\ P_2(t) \\ P_3(t) \end{bmatrix} = \begin{bmatrix} -\lambda_1 & \mu & 0 \\ \lambda_1 & -\lambda_2-\mu & \mu \\ 0 & \lambda_2 & -\mu \end{bmatrix} \cdot \begin{bmatrix} P_1(t) \\ P_2(t) \\ P_3(t) \end{bmatrix}.$$

Draw the Markov chain corresponding to this set of equations.

8) **(6 points)** Construct the parity check matrix H and the generator matrix G for a linear code for 7-bit data which can correct 1 error and detect one additional error. Use as few check bits as possible.

9) **(2 points)** Consider the following parity check matrix, corresponding to a $(7,4)$ linear code:

$$H = \begin{bmatrix} 1 & 1 & 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Is this code a Hamming code?

10) **(5 points)** Construct the generator matrix G for a (7,4) cyclic code which can detect any burst error of length 3.

11) **(5 points)** (a) Draw an LFSR for decoding for a cyclic code with generator polynomial $g(x) = 1 + x^2 + x^5$.

b) Encode the data $1 + x^3 + x^4$.

c) Suppose that the error $1 + x + x^2$ is added to the codeword you obtained in the previous task. Check whether this error will be detected.

d) Is $c(x) = x^{10} + x^5 + x^4 + x^2 + 1$ a valid codeword in this code?

12) **(3 points)** Check whether the function $f(a,b,c) = abc$ is self-dual.

13) **(5 points)** Suppose you have a 3-input 3-output logic circuit implementing the following functions:

(a) $f_1(a,b,c) = ac + b.$
(b) $f_2(a,b,c) = abc$
(c) $f_2(a,b,c) = ab + c$

Encode the outputs of this circuit in the Berger code in order to make the circuit self-checking. Show the resulting check bits in a truth table (as in the lecture).