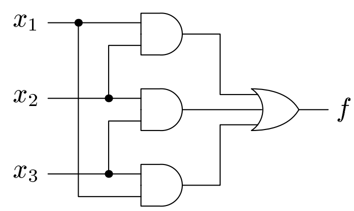
2B1453 Final Exam (60 points)

May 22, 2002

Name:

PN:

(**7 pt**) 1) Find tests for single stuck-at-0 and single stuck-at-1 faults for all primary inputs of the following circuit:



Give your answer in the following format:

s-a-0 at x_1 : (xxx)
s-a-1 at x_1 : (xxx)
...
s-a-1 at x_3 : (xxx)

where (xxx), $x \in \{0, 1, -\}$, stands to the assignment of input values representing your test. The symbol "$-$" means "can be both, 0 or 1".

(**3 pt**) 2) An automatic teller machine manufacturer determines that his product has a constant failure rate of $\lambda = 77.16$ per 10^6 hours in normal use. For how long should the warranty be set if no more than 3% of the machines are to be returned to the manufacturer for repair?

(**3 pt**) 3) Suppose the failure rate of a jet engine is $\lambda = 10^{-3}$ per hour. What is the probability that more than two engines on a four-engine aircraft will fail during a 4-hour flight? Assume that the failures are independent.

(**2 pt**) 4) A printer has an MTTF = 168 hr and MTTR = 3 hr. What is the steady state availability?

(**5 pt**) 5) Suppose that the reliability of a system consisting of 4 blocks, two of which are identical, is given by the following equation

$$R_{system} = R_1 R_2 R_3 + R_1^2 - R_1^2 R_2 R_3$$

Draw the reliability block diagram representing this system.

(**5 pt**) 6) Write the reliability expression for passive hardware redundancy system with 5 modules (5MR). Assume that the reliability of each module is R_M and the reliability of the voter is R_V.

(**10 pt**) 7) Construct a Markov model and write a transition matrix for self-purging redundancy with 3 modules, for the cases listed below. For all cases, assume that the component's failures are independent events and that the failure rate of each module is λ. For all cases, simplify state transition diagrams as much as you can. Recall that, in self-purging redundancy, the voter can be adopted to vote on less inputs.

(a) Do reliability evaluation, assuming that the voter can fail with the failure rate λ_v, the switches are perfect, and no repairs are allowed.

(b) Do availability evaluation, assuming that the voter and switches are perfect and repairs are allowed. Assume that there is a single repair crew for all modules that can handle only one module at a time and that the repair rate of each module is μ.

(**7 pt**) 8) Construct the parity check matrix H and the generator matrix G of a linear code for 5-bit data which can correct 1 error. Recall that a parity check matrix is of size $k \times n$, and a generator matrix is of size $d \times n$, where d, k and n is the number of bits in data, check-bits and codeword, respectively.

Use **as small** k **as possible**.

(**7 pt**) 9) Construct the parity check matrix H and the generator matrix G of a Hamming code for 11-bit data.

(7 pt) 10) a) Develop an LFSR for decoding of 4-bit data using the generator polynomial $g(x) = 1 + x^2 + x^3$.

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 $c(x) = x^6 + x^5 + x^3 + 1$ a valid codeword?

(**4 pt**) 11) List all codewords for a Berger code for 4-bit data. What is the code distance of the resulting code?