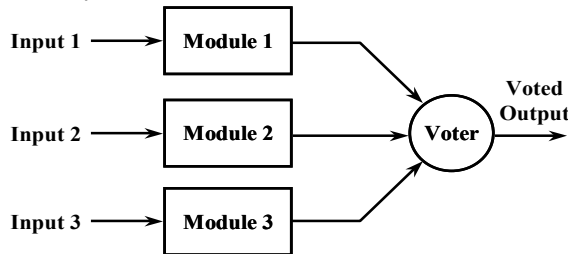


**ECE544 Fault-Tolerant Computing & Reliability Engineering**  
**Midterm Exam Sample Questions (Fall 2022)**

1. Considers the following two competing fault-tolerant designs that can tolerate 1 fault:  
**Design #1 (2-out-of-3: G system):** consists of three identical components working concurrently; the system is Good (i.e., functioning) if 2 or more out of the three components are working correctly.  
**Design #2 (3-out-of-4: G system):** consists of four identical components working concurrently; the system is functioning if three or more out of the four components are working correctly.  
 Assume all components used in the two designs have a fixed reliability of  $p=0.7$  for a prescribed time. Which design is more reliable? Please justify your answer by computing the reliability of each design.
2. For a 4-bit data word  $(d_0, d_1, d_2, d_3)=(0111)$ , determine
  - a). if the word  $(v_0, v_1, v_2, v_3, v_4, v_5, v_6)=(0100011)$  is its valid non-separable  $(7,4)$  cyclic code word with the generator polynomial being  $G(X)=1+x+x^3$ . Justify your answer.
  - b). if the word  $(v_0, v_1, v_2, v_3, v_4, v_5, v_6)=(0110011)$  is its valid Hamming SEC code word or not. Justify your answer.
3. A bulb with an exponential time-to-failure distribution has the mean time to failure of 10000 hours.
  - a). Determine the failure rate of the bulb.
  - b). Find the probability that the bulb will survive its MTTF in continuous operation.
  - c). Determine the probability that the bulb will fail within 15000 hours, when you know that the bulb was functioning at 5000 hours.
  - d). Find the mean residual life (MRL) of the bulb at age  $t=70000$ hours.
4. Consider a Triple Module Redundancy (TMR) system as shown in the following figure. Suppose all the three modules fail independently and exponentially with the same constant failure rate  $\lambda=0.0001$ /hour. The voter fails with the fixed probability of 0.001.
  - a). Show the fault tree model of this TMR system.
  - b). Find all the minimal cut sets.
  - c). Find the system unreliability for time  $t=1000$  hours



Note: for simplicity, you may use M1, M2, M3, and V to denote the three modules and the voter in your answers.

5. (Hands-on problem on Slide 35, Lecture #9) Consider the fault tree below modeling the failure of a system. Assume the occurrence probabilities of basic events are:  $\Pr(E1)=0.1$ ,  $\Pr(E2)=0.05$ ,  $\Pr(E3)=0.01$ ,  $\Pr(E4)=0.02$ . Determine the system failure probability.

