



TECHNICAL UNIVERSITY OF MOMBASA

FACULTY OF ENGINEERING AND TECHNOLOGY

MEDICAL ENGINEERING DEPARTMENT

UNIVERSITY EXAMINATION FOR:

DEGREE

EEE 4503: RELIABILITY ENGINEERING

END OF SEMESTER EXAMINATION

SERIES: AUGUST 2024

TIME: 2 HOURS

DATE:

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of FIVE questions. Attempt Question 1, Compulsory and any other Two Questions.

Do not write on the question paper.

QUESTION ONE (Compulsory)

- a) Define the following reliability terms **[3 MARKS]**
- i. Failure analysis
 - ii. Failure rate
 - iii. Derating
- b) Highlight any three factors that play a key role in increasing the importance of reliability in design systems **[3MARKS]**
- c) The system shown in Figure Question 1(c) is made up of 10 components, Components 3, 4 and 5 are identical and at least one component of this group must be available for the system success. Components 8, 9 and 10 are NOT identical and for this particular

group, it is necessary that two out of three components functions satisfactory for the system success.

- i) Write an expression for the system reliability in terms of R value given
- ii) Evaluate the system reliability if the reliability of 8, 9 and 10 are 0.8, 0.90, and 0.95 respectively, while all other components have similar reliabilities of 0.85

[12Marks]

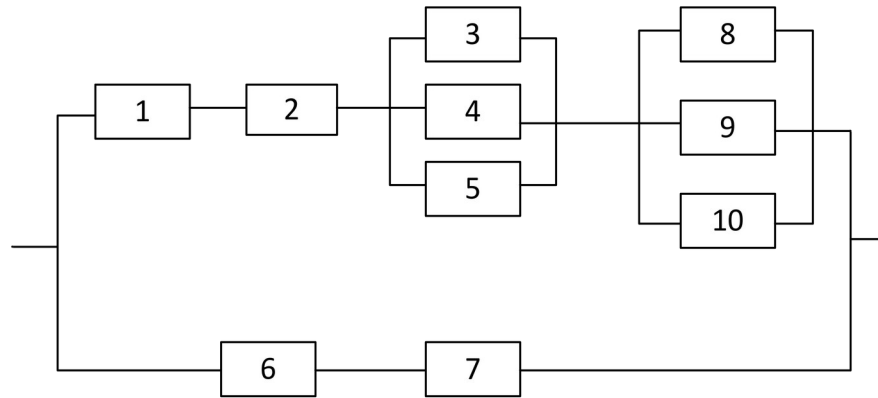


Figure Question 1(c)

- d) By making appropriate assumptions, show that $R_{(t)} = e^{-\lambda t}$ [3MARKS]
 - iii) A computer system has five identical terminals in series. The required system reliability for unit time (T=1) hour is $R(1) = 0.999$. Calculate the components
 - i) Reliability
 - ii) Unreliability
 - iii) Failure rate values [3MARKS]
- e) Name and explain **TWO** Reliability Engineering techniques used in failure identification and correction [6 MARKS]

QUESTION TWO

- a) Compare and contrast the following
 - i) Engineering maintainability versus engineering maintenance
 - ii) Corrective versus preventive maintenance [4MARKS]
- b) Explain the need of the following maintainability design goals;
 - i) Standardization
 - ii) Modular design [2 MARKS]
- c) i) Give and explain **FOUR** main categories of corrective maintenance [4 MARKS]
 - iii) What are the seven basic RCM (Reliability Centred Maintenance) steps

[4 MARKS]

- d) A large generator system designed for continuous operation fails 5 times in a period of 2 years. If the total time for the repairs during the period is 30 days, determine:
- i) MTTR (days)
 - ii) MTBF(days)
 - iii) Unavailability of the plant due to the break down
- [6 MARKS]

QUESTION THREE

- a) Highlight any Three objectives of maintenance engineering
- b) State three main reasons for safety problems in maintenance and highlight three design guidelines for improving safety in maintenance [6 MARKS]
- c) 1000 similar components which are known to have a constant failure rates of 5% per 1,000 hrs, are put into operation at the same time; calculate the predicted time which will elapse before [6 MARKS]
- i. 50
 - ii. 500 equipment's have failed in service
- d) A telemetry transmission system of an earth satellite has an MTBF of 10000 hours. Estimate the probability of no failures during 1000, 90 mins' orbits [4 MARKS]
- e) For the reliability block diagram of Figure Qn 3 list at least your two sets for each of the following
- a) Tie-set
 - b) Cut-set
 - c) Minimum tie-set
 - d) Minimum Cut-set

[4

MARKS]

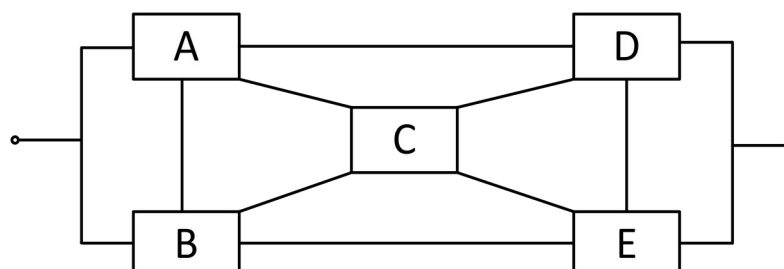


Figure Qn 3(b)

QUESTION FOUR

- a) List and explain guideline steps that can be used to develop an effective preventive maintenance program **[6 MARKS]**
- b) Assume that an engineering system is composed of three independent and identical units in parallel. At least two units must operate normally for system success. Determine:
- i) System reliability
 - ii) System mean time between failures if the unit failure rate is 5×10^{-4} failure per hour. **[6 MARKS]**
- c)
- i) Highlight three costs involved when an equipment experiences a sudden and complete failure.
 - ii) 3,000 identical equipment's with a constant failure rate of 1.5% per 1000hrs are put in to operation at the same time: Calculate the predicted time which will elapse before 2000 such equipment failed in service. **[8 MARKS]**

QUESTION FIVE

- a) Describe the key elements of the following reliability-centred maintenance program:
- i) Reactive maintenance
 - ii) Predictive testing
 - iii) Proactive maintenance **[6 MARKS]**
- b) A machine with a constant failure rate λ and a probability of 0.97 survives a period of 200 hrs without failure. Determine:
- i) The failure rate in % per 1000hrs
 - ii) The MTTF of the machine **[8 MARKS]**
- c) With the aid of a sketch, show that the average cost of running an engineering asset is given by:

$$P_{(n)} = \frac{(C - S) + R_{(n)}}{n}$$

Where: C is the capital required to purchase a new asset

S is the salvage value

$R_{(n)}$ is the running cost in n years?

- f) Cost analysis of a machine found that the average cost per year is Kshs. 2,643. The capital cost C= Kshs. 15,000 and the salvage value= Kshs. 1,000. Find the number of years' n for which the total running cost will be Kshs. 7,500. **[6 MARKS]**