



MACHAKOS UNIVERSITY

University Examinations for 2020/2021

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

FIFTH YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (ELECTRICAL AND ELECTRONICS ENGINEERING)

EEE 543: RELIABILITY ENGINEERING

DATE: 13/8/2021

TIME: 2:00 – 4:00 PM

INSTRUCTIONS:

Answer Question one and any other two

QUESTION ONE (COMPULSORY) (30 MARKS)

- a) Define and explain the 3 types of availability (6 marks)
- b) The life of a lamp is normally distributed, with mean 1200h and SD 200h. What is the probability that a lamp will last (4 marks)
- (i) at least 800h
- (ii) at least 1600h
- c) An aircraft landing gear has 4 tires. Experience shows that tire bursts occur on average on 1 landing in 1200. Assuming that tire bursts occur independently of one another, and that a safe landing can be made if not more than 2 tires burst, what is the probability of an unsafe landing (9 marks)
- d) A salvo with two missiles is fired. The reliability of a missile is 0.85. Determine the probability that at least one missile hits the target if: (4 marks)
- (i) Assume independence of missile hits

- (ii) Assume dependence of missile hits such that if the first missile fails the probability that the second will also fail is 0.2
- e) Define reliability (2 marks)
- f) A solid state radar is subject to preventive maintenance after every 400 flight hours. The time to failure of the radar follows exponential distribution with mean life 800 flight hours. Find the MTTFpm of the radar (5 marks)

QUESTION TWO (20 MARKS)

- a) Avionics system of an aircraft consists of digital auto-pilot, integrated global positioning system, weather and ground mapping radar, digital map display and warning system. Apart from the above items, the avionics system has control software. The time-to-failure distributions of various items are given in Table 1. Find the reliability of the avionics system for 100 hours of operation if all the items are necessary to maintain the required function of the avionics system (8 marks)

Table 1

Item	Time-to-failure distribution	Parameter values
Digital autopilot	Exponential	$\lambda = 0.003$
Integrated global positioning system	Weibull	$\eta = 1200, \beta = 3.2$
Weather and ground mapping radar	Weibull	$\eta = 1000, \beta = 2.1$
Digital map display	Normal	$\mu = 800, \sigma = 120$
Warning System	Normal	$\mu = 1500, \sigma = 200$
Software	Exponential	$\lambda = 0.001$

- b) A system consists of three items connected in series. The time-to-failure distribution and their corresponding parameter values are given in Table 2. Find (12 marks)
- the mean time to failure of the system.
 - mean time to failure of individual items.

Table 2

Item	Distribution	Parameter values
Item 1	Weibull	$\eta_1 = 10, \beta_1 = 2.5$
Item 2	Exponential	$\lambda = 0.2$
Item 3	Weibull	$\eta_2 = 20, \beta_2 = 3$

QUESTION THREE (20 MARKS)

- a) The time to failure distribution of a steam turbo generator can be represented using Weibull distribution with $\eta = 500$ hours and $\beta = 2.1$. Find (7 marks)
- the reliability of the generator for 600 hours of operation.
 - the hazard function of the system at time $t = 100$
- b) Explain 5 disadvantages of Failure-Based Maintenance Policy (5 marks)
- c) Discuss the hazard function using an illustration of the bath tub curve (8 marks)

QUESTION FOUR (20 MARKS)

- a) Time to failure distribution of a digital engine control unit (DECU) follows an exponential distribution with mean time between failures 1200 hours and the repair time also follows an exponential distribution with mean time to repair 400 hours. (12 marks)
- Sketch the point availability of the DECU.
 - Find the average availability of the DECU during first 5000 hours.
 - Find the inherent availability

b) A Systems is defined as follows

- **Hazard:** Toxic chemical released

- **Design:**

Tank includes a relief valve opened by an operator to protect against over-pressurization. A secondary valve is installed as backup in case the primary valve fails. The operator must know if the primary valve does not open so the backup valve can be activated.

Operator console contains both a primary valve position indicator and a primary valve open indicator light.

Draw the fault tree diagram for this hazard and system design (8 marks)

QUESTION FIVE (20 MARKS)

- a) Explain 4 limitation of Fault Tree Analysis (4 marks)
- b) Why is redundancy necessary and how is it achieved (3 marks)
- c) A series system consists of four items. The time to failure and the time to repair distributions of the different items as given in Tables 3 and 4. Find the inherent availability of the system (13 marks)

Table 10.1. Time to failure distribution for different items.

Item Number	Distribution	Parameters
Item 1	Weibull	$\eta = 2200$ hours $\beta = 3.7$
Item 2	Exponential	$\lambda = 0.0008$ per hour
Item 3	Weibull	$\eta = 1800$ hours $\beta = 2.7$
Item 4	Normal	$\mu = 800$ hours $\sigma = 180$ hours

marks)

Table 4 . Time to repair distribution for different items

Item number	Distribution	Parameters
Item 1	Lognormal	$\mu_l = 3.25$ and $\sigma_l = 1.25$
Item 2	Normal	$\mu = 48$ hours $\sigma = 12$ hours
Item 3	Lognormal	$\mu_l = 3.5$ and $\sigma_l = 0.75$
Item 4	Normal	$\mu = 72$ hours $\sigma = 24$ hours