CRE Sample Test #2.

1. Which answer is the expected value of the Poisson distribution shown below?

\[ P(x = k) = \frac{e^{-\mu} \mu^k}{k!} \quad k = 0, 1, 2, 3,... \]

A. \( \mu \)  
B. \( \mu e^{-\mu} \)  
C. \( e^{-\mu} \)  
D. \( \mu^2 \)

2. FMECA is:
A. A professional engineering organization.
B. A formal technique for review of failure potentials during design.
C. A technique to assure that design performance guidelines are fulfilled.
D. A technique useful for space-government project.

3. For the equation shown below, the maximum likelihood estimator:

\[ \hat{\sigma}^2 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n} \]

A. Is a biased estimator.  
B. Is an unbiased estimator.  
C. Is an estimated the mean  
D. Is missing a term.

4. For the ANOVA Table below, what is the \( F_{cal} \) statistic?

<table>
<thead>
<tr>
<th>Source</th>
<th>Sum of Squares</th>
<th>Degrees of Freedom</th>
<th>Mean Squares</th>
<th>( F_{cal} )</th>
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<td>Error</td>
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<tr>
<td>Totals</td>
<td>630</td>
<td>15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A. 9.44  
B. 1.58  
C. 5.64  
D. 5.97
5. Extrapolation is a method of reliability prediction which involves primarily:
   A. Engineering judgment. B. FRACAS techniques.
   C. Mathematical calculation and measurement. D. FTA and FEMA analysis.

6. For human factors testing, the reliability engineer should understand and consider which of the following?
   I. Sight capabilities.
   II. Touch capabilities.
   III. Audio capabilities.
   IV. Thermal capabilities.
   V. Vibration capabilities.
   A. I, II, III B. II, III, IV, V
   C. I, II, III, V D. I, II, III, IV, V

7. What is the minimum number of failure free trips that one must make in their car to be at least 95% confident it is 95% reliable?
   A. 22 B. 45 C. 58 D. 102

8. The BEST way to set an overall reliability goal is to:
   A. Write a specification calling for a product to have high reliability and incorporate it into a contract.
   B. Put down specific numerical requirements for reliability statements of operating environments, and a definition of successful product performance.
   C. Insist that the goal be expressed in terms of mean-time-between-failures for all components and assemblies.
   D. Indicate who would be at fault if the desired reliability is not obtained during the warranty.

9. Which of the following is a basic element in the corrective action process?
   A. Limit manufacturing expenses. B. Identify failure for trend analysis.
   C. Investigate problems to determine root causes. D. Apply Pareto analysis to failure.
10. What is the difference between a system whose reliability prediction is MTTF versus one whose reliability prediction is MTBF?
   A. There is no difference. Both terms mean essentially the same.
   B. MTTF implies that the system can't be repaired. MTBF implies that it can be.
   C. MTBF implies that the system can't be repaired. MTTF implies that it can be.
   D. MTTF is used for maintainability studies. MTBF is used for reliability studies.

11. Looking at systems in terms of (1) a series-parallel functional configuration, (2) using a truth table approach, or (3) performing a Monte-Carlo simulation are techniques for:
   A. Trade-off studies.  
   B. Sneak circuit analysis.
   C. Modeling systems. 
   D. Fault tree analysis.

12. What is the probability of exactly 3 defects given the following?
   - Probability of 1 or more defects = 0.75
   - Probability of 2 or more defects = 0.41
   - Probability of 3 or more defects = 0.17
   - Probability of 4 or more defects = 0.05
   A. 0.12
   B. 0.17
   C. 0.24
   D. 0.22

13. When reliability deterioration of a system can be associated with independent and small multiplicative effects of its components, the applicable time-to-failure distribution is:
   A. Lognormal.  
   B. Extreme value.
   C. Exponential. 
   D. Weibull.

14. Typical statistical distributions or confidence limits can be determined for accelerated tests. In the case of a step-stress test, the proper estimated distribution would be which of the following?
   A. Exponential. 
   B. Weibull. 
   C. Lognormal. 
   D. None, not meaningful.
15. What is the difference between an active parallel system and a shared load parallel system?
   A. There is no significant difference.
   B. In the shared load parallel system, the load is equally shared between the two parallel components.
   C. The shared load parallel system is a type of active parallel system.
   D. The failure rate of the remnant component increases in the shared load parallel system on first component failure.

16. Which of the following techniques is MOST effective for incorporating desired attributes into the earliest stages of product design?
   A. FTA   B. FRACAS   C. QFD   D. FMEA

17. Total productive maintenance seeks to eliminate the "six big losses". Which of the following are included in that category?
   I. Process defects.
   II. Environmental losses.
   III. Setup losses.
   IV. Equipment failures.
   A. I and IV only   B. I, III and IV only
   C. II, III and IV only   D. I, II, III and IV

18. The "least squares" description in regression analysis pertains to:
   A. Sums of the squares of the deviations from the predictions.
   B. Averages of the predicted values.
   C. The error term in the equation.
   D. The average of the actual data minus the average of the predicted data.

19. If a company monitors field reliability using both three month and yearly MTBF moving averages, a comparison of the averages will generally show that the yearly moving averages:
   A. Are greater than the 3 month values.
   B. Are less than the 3 month values.
   C. Vary more than the 3 month values.
   D. Vary less than the 3 month values.
20. Reliability testing plans may encompass:
   I. Fixed length tests.
   II. Probability ratio sequence tests.
   III. Longevity tests.

   A. I only   B. II only   C. II and III only   D. All of the above

21. In standby parallel systems, imperfect switching means:
   I. The switch is not perfect.
   II. The secondary unit is on back-up.
   III. The reliability of the system is less than with perfect switching.
   IV. The secondary unit has the same reliability as the primary unit.

   A. I        B. I and II    C. I, II and III   D. All of the above

22. A field test may be considered satisfactory if:
   A. The design engineer can operate the equipment under all required conditions.
   B. The reliability engineer can operate the equipment under all required conditions.
   C. Alternate operators can operate the equipment under all required conditions.
   D. The human factors engineers can operate the equipment under all required conditions.

23. Failure occurs on a system at 75, 79, 83, 85 hours. Assuming normality, one sided and unbiased the lower tolerance limit for 95% reliability with 90% confidence for this sample is:
   A. 96 hours.   B. 60 hours.   C. 100 hours.   D. 63 hours.

24. What is the expression for operation availability?
   A. Operation time / [operate time + total down time].
   B. Active down time / operate time.
   C. Operation time / total down time.
   D. Off time / operate time.
25. Measures of availability include:
   I. Effectiveness.
   II. Inherent.
   III. Achieved.
   IV. Dependability.
   V. Capability.

26. In a design team environment, the reliability function can influence product reliability principally by:
   A. Integrating the reliability requirements into product design.
   B. Developing reliability tests and procedures.
   C. Conducting internal and external failure analyses.
   D. Providing repair and maintenance service information.

27. An item was removed from testing after 25 hours without failing. This unit was:
   I. Right censored.
   II. Suspended.
   III. Truncated.

28. A good practice in selection of components is to select standard parts. The valid reasons include:
   I. Standard parts are generally proven and at a cost advantage.
   II. Use of standard parts sometimes reduces the number of different parts.
   III. Standard parts are usually more technically innovative.
   IV. Standard parts might prevent inventory expansion.
   V. Standard parts usually are free from schedule concerns.
29. The failure data collection, analysis, and corrective action system:
   I. Should include failures due to equipment failure and those due to human error in designing, manufacturing, and operating the equipment.
   II. Should include elapsed operating time (or cycles) prior to failure.
   III. Should include all failures from initial development through acceptance testing.
   A. I  B. II, III  C. I, III  D. All of the above.

30. If the elements in the following logic diagram are independent, reliability is:

   ![Logic Diagram]

   A. 0.8486  B. 0.9412  C. 0.9960  D. 0.9987

31. Balancing a reliability requirement against other design parameters, such as performance, cost, or schedule, and then analyzing the consequences of placing special emphasis on one of these factors is called
   A. Reliability allocation.  B. Trade-off decisions.
   C. Reliability predictions.  D. System modeling.

32. Which of the following tests are always performed on production items?
   I. Demonstration Tests.
   II. Qualification Tests.
   III. Screening Tests.
   A. I  B. I and II  C. III  D. All of the above.
33. TAAF is BEST performed at which stage of the product life-cycle?
   A. Concept/planning.  
   B. Design/Development.  
   C. Production/Manufacturing.  
   D. Operation/Repair.

34. Specifications are written on parts to:
   I. Enable procurement to buy usable parts.
   II. Establish mechanical, functional, environmental and reliability requirements.
   III. Provide inspection criteria.
   
   A. I  
   B. I and II  
   C. III  
   D. All of the above.

35. A reliability test was terminated after 171 hours based upon a pre-established plan. An estimate of mean-time-to-failure of 57 hours was obtained. The lower 95 percent confidence bound on the true population mean-time-to-failure is:
   A. 125 hours.  
   B. 22 hours.  
   C. 27 hours.  
   D. 11 hours.

36. Which of the following is a discrete probability distribution?
   A. Normal.  
   B. Weibull.  
   C. Binomial.  
   D. Lognormal.

37. For equal length missions an increase in the MTBF will yield:
   I. An increase in availability.
   II. An increase in reliability.
   III. A decrease in reliability.
   IV. A decrease in availability.
   
   A. I  
   B. I and II  
   C. III  
   D. III and IV
38. The predicted reliability is higher than the long term realized probability. Which of the following is the most likely cause of this difference?
A. Deterioration of the manufacturing processes and procedures.
B. Lack of adequate employees training and process audits.
C. The accumulation of random process variations.
D. A poor initial estimation of reliability.

39. In the classification of defectives, such as DOD-STD-2101, if an item will produce a significant degradation in performance, the classification would be:

40. Inherent availability may be increased by:
A. Decreasing MTBF. B. Increasing MTTR.
C. Decreasing MTTR. D. None of the above.

41. Large power generating stations frequently have auxiliary turbine generators operating at speed. They do not produce power but act as back-ups. This type of redundancy is known as:
A. Active parallel system. B. Stand-by parallel system.
C. Shared load parallel system. D. Bayes’ theorem application.

42. A FMEA can be performed using all of the following EXCEPT:
C. Bottom-up analysis. D. Life cycle costs.
43. Production error by human operators may be caused by:
   I. Inadequate work space.
   II. Inadequate job planning information.
   III. Poor environmental conditions.
   A. I     B. I and III    C. II   D. All of the above

44. Given a reliability growth test in progress having accumulated 4 failures during 5000 test hours. Assume a growth rate of 0.3, what is the expected MTBF at 25,000 hours?

45. A "fail-safe" requirement means:
   A. The system is safe from failure.   B. The system will fall in a safe state.
   C. The system has safety devices.    D. The safety systems cannot fail.

46. An engineer must design a product with a probability of success 99%. Assume that both the strength and stress are normally distributed and that the standard deviations are the same. If the stress is known to be 3000 lbs with a standard deviation of 100 lbs, what must be the approximate designed strength?

47. Which test would potentially take longer than expected to complete?
   I. Time terminated tests.
   II. Failure terminated tests.
   III. Sequential tests (PRST)
   A. I     B. II      C. I and III    D. All of the above
48. Product residual safety risk includes which two of the following?
   I. The risk left over after the risk reducing plan is implemented.
   II. The risk associated with the selected part.
   III. The risk associated with a safety device.
   IV. The risk the user introduces when they modify a product.

   A. I and III       B. II and III       C. II and IV       D. III and IV

49. The fundamental philosophy of Optimum Parts Replacement is:
   A. To prevent failures.
   B. To minimize maintenance costs.
   C. To minimize failure costs.
   D. To minimize the total of maintenance and failure cost.

50. In the binomial expression:
   A. The sum of the exponents of each term after expansion is equal to the sample size.
   B. The sum of the coefficients of each term after expansion is equal to the sample size.
   C. The sum of the exponents of all the terms after expansion is equal to the sample size.
   D. The sum of the exponents after expansion has no relation to the sample size.

51. Equivalence class partitioning is:
   A. A black-box method that divides program functions into related groups for testing.
   B. A white-box method that divides control paths into dependent and independent categories for testing.
   C. A black-box method that divides the inputs to a program into classes from which test cases can be derived.
   D. A white-box method that divides errors into classes to reduce the amount of testing required.
52. What is meant by catastrophic failure?

I. A gradual change in the operating characteristics of an item resulting in no loss of useful performance.

II. A sudden change in the operating characteristics of an item resulting in complete loss of useful performance.

III. A gradual change in the operating characteristics of an item resulting in complete loss of performance.

A. I  B. II  C. II and III  D. All of the above.

53. The main reason for the use of Quality Function Deployment (QFD) is which of the following?

A. To implement the voice of the customer.

B. To ensure concurrent engineering.

C. To assign responsibilities for product designs.

D. To provide a structured product design approach.

54. Which of the following are the MOST desirable basic skills required of a reliability engineer assigned to a cross-functional product team?

A. Reliability trouble shooting, data collection and analysis.

B. Experience with FMECA and FTA.

C. Reliability planning, testing and measurement.

D. Communication, co-operation, and technical knowledge.

55. Design review should be a process to ensure and/or develop more reliable design. Which of the following person(s), if any, should work with the designer during the design process?

A. Reliability engineer.  B. Designer only.

C. Management team.  D. Design supervisor.
56. A Pareto analysis of field failure data indicates that several significant failure categories are approximately equal in size. The BEST next course of action to take in selecting a category for improvement would be which of the following?
   A. Take additional data until a more significant category is evident.
   B. Select the category that offers the most overall cost saving.
   C. Select the category that is easiest to fix.
   D. Select the category that requires the least expense to fix.

57. The linear graphs which accompany Taguchi designs have as their objectives:
   I. Providing a compact design layout.
   II. Providing a visualization of the design options.
   III. Depicting where main factors can be assigned.
   IV. Depicting where interactions may be evaluated.
   A. II  B. I, II, III  C. II, III, IV  D. All of the above

58. A substantial fraction of the usual design effort need NOT be devoted to a reliability program:
   A. When the equipment is complex.
   B. When time is limited.
   C. When high reliability is specified.
   D. When high reliability is not specified.

59. The means of large samples from a population tend to be normally distributed around the population mean. This statement is TRUE according to which of the following theorems?
   A. Central limit.
   B. Camp-Meidel.
   C. Tchebysheff’s
   D. Least squares.

60. For a steady state large system reliability prediction which of the following distribution is normally used?
   A. Poisson.
   B. Exponential.
   C. Normal.
   D. Weibull.
61. For a high compression aircraft air conditioning system, the MTBF is 100 hours. This mean life is allocated for four serial units comprising the total system. The unit failure rates are then weighted as follows:

\[
\begin{align*}
    w_1 &= 0.1250 \\
    w_2 &= 0.2500 \\
    w_3 &= 0.1875 \\
    w_4 &= 0.4375
\end{align*}
\]

Based upon the above data, indicate which of the following is the correct calculation for one of the units.

A. \(\lambda_3 = 0.0018750\)  
B. \(\lambda_4 = 0.0435700\)  
C. \(\lambda_1 = 0.0125000\)  
D. \(\lambda_2 = 0.0025100\)

62. Given mean-time-to-failure for three components as \(M_1 = 100\) hours, \(M_2 = 500\) hours, \(M_3 = 1000\) hours; what is the mean-time-to-failure of the system if the three components are in series?

A. 160 hours.  
B. 100 hours.  
C. 77 hours.  
D. 13 hours.

63. A person takes their car to the repair shop and it stops doing what it was previously doing. This is an example of:

A. Catastrophic failure.  
B. Degradation failure.  
C. Intermittent failure.  
D. Drift failure.

64. Reliability is affected by which of the following?

I. Design.  
II. Production.  
III. Field service.  
IV. User.

A. I, III  
B. I, II, III  
C. II, III, IV  
D. All of the above.
65. The reliability of a device comprised of various parts functioning in series is the:
   A. Product of the reliabilities.
   B. Sum of the probabilities of the unreliabilities.
   C. Product of the unreliabilities.
   D. Sum of the reliabilities.

66. To conduct accelerated life tests, which of the following assumptions must be made?
   I. The severity of the stress levels does not change the life distribution.
   II. The Arrhenius model is normally followed.
   III. The relationship between the stress level and the life distribution is known and valid.
   IV. The testing is conducted at a stress level equivalent to or near failure conditions.
   A. I       B. I, III      C. II, III    D. All of the above

67. Parts in use during the "wear out" portion of the part life cycle curve will exhibit:
   A. A constant failure rate.
   B. A low failure rate.
   C. A decreasing failure rate.
   D. An increasing failure rate.

68. When testing is establish failure rate data and reliability predictions, which of the following is NOT normally a feasible acceleration factor with respect to rated conditions?
   A. Longer time.
   B. Greater humidity.
   C. Higher temperature.
   D. Higher voltage.

69. Maintenance repair tasks in a large scale system with constant repair rates follow which of the following distributions?
   A. Normal.
   B. Exponential.
   C. Lognormal.
   D. Geometric.
70. The purpose of a failure reporting, analysis and corrective action system (FRACAS) includes which two of the following?
   I. Provide a closed loop failure reporting system.
   II. Provide initial robust product designs.
   III. Provide management with derating methods and principles.
   IV. Provide a failure analysis and corrective action vehicle.

A. I, II  B. II, III  C. I, IV  D. II, IV

71. Which of the following is NOT an objective of a data collection program?
   A. To demonstrate reliability to customers.
   B. To produce reliability reports.
   C. To demonstrate internal reliability.
   D. To validate vendor supplied items.

72. A failure that leaves the system fully functional is:
   C. A minor failure.  D. A major failure.

73. Which of the following are specific failure types?
   I. Catastrophic.
   II. Drift.
   III. Intermittent.
   IV. Degradation.

A. I and III only  B. II and III only
C. I, II and III only  D. I, II, III and IV
74. Computerized data collection and storage is MOST appropriate when:
   A. The principal failure modes are not apparent.
   B. Discrete attribute data is under review.
   C. A considerable amount of complex data must be processed.
   D. Human error is anticipated in the data collection process.

75. Which one of the following would NOT be necessary in a corrective action status report?
   A. Due date.
   B. Failure cost.
   C. Responsible function (department).
   D. Failure identification.

76. Which of the following actions would usually be performed FIRST after receiving a product failure from the field?
   A. Verification of failure.
   B. Estimate possible causes.
   C. Assignment of investigative actions.
   D. Determine possible mode of failure.

77. A data collection, analysis, and reporting system should:
   I. Permit detailed failure and failure rate analysis for varying environments, time periods, storage conditions, etc..
   II. Provide distinction between items that failed and item that were wrongly removed.
   III. Report data on successes as well as failures.
   A. I only
   B. II and III only
   C. I and II only
   D. I, II, and III

78. Which one of the following quantitative methods does NOT apply to the assessment of actual system/component reliability?
   A. Statistical analysis of field test data.
   B. Statistical allocation of reliability goals.
   C. Evaluation of laboratory and acceptance test data.
   D. Analysis of result for reliability demonstration test.
79. The prediction technique has obviously not always been effective quantitatively. There is often a wide difference between actual reliability and predicted reliability. Nevertheless, the reliability prediction technique permits:

A. Separating out "the vital few" from the "trivial many".
B. Spotlighting what has gone wrong with the program.
C. Indicating which department is to blame.
D. Estimating how good the product really is.

80. Analysis of data on all product returns is important because:

I. Failure rates change with length of product usage.
II. Changes in design and in customer use are often well reflected.
III. Immediate feedback and analysis of product performance becomes available.

A. I only  B. I and III only  C. II and III only  D. I, II and III

81. When performing trade-offs in evaluating parts for reliability, which of the following is LEAST important?

A. Technical comparison of new part with standard part type.
B. Search of data part history to established reliability potential.
C. Process and materials compatibility.
D. Initial parts costs.

82. Censoring of reliability data indicates which of the following?

I. Biased product data is used.
II. Testing has been failure terminated.
III. The data collection is time limited.
IV. Questionable data collection methods are used.

A. I and III only  B. II and III only  C. I and IV only  D. II and IV only
83. Test, analyze and fix (TAAF) programs typically include:
   I. Failure Reporting and Corrective Action Systems (FRACAS).
   II. Reliability Growth Testing (RGT).
   III. Environment Stress Testing (ESS).
   IV. Failure free qualification testing.

   A. I and II only.  B. II and III only.  C. I, II and III.  D. II and IV only.

84. The design function which assigns probability of failures between components or subsystems is called:
   A. Confidence.  B. Significance.  C. Apportionment.  D. Qualification.

85. A component fails on the average of once every 4 years with 75% of the failures observed to occur during stormy weather. If there are 12 hours of stormy weather to every 240 hours of good weather, what are the failure rates for stormy and good weather respectively?
   A. \( \lambda \) (stormy) = 3.938, \( \lambda \) (good) = 0.0656 failures/yr
   B. \( \lambda \) (stormy) = 4.202, \( \lambda \) (good) = 0.0525 failures/yr
   C. \( \lambda \) (stormy) = 6.594, \( \lambda \) (good) = 0.0458 failures/yr
   D. \( \lambda \) (stormy) = 4.000, \( \lambda \) (good) = 0.0655 failures/yr

86. Root cause failure analysis is necessary to identify and correct basis problems. Usually a priority of failure mode is established. This classic or traditional approach to improvement results in which of the following?

87. What is the \( Z \) value needed to conduct a two tail test in a statistical inference problem, specifying 90% level of confidence?
   A. 1.96  B. 1.28  C. 1.65  D. 2.24
88. The probability of survival (or, reliability), using an exponential distribution can be defined by which of the equations on the left?

Where

- \( R_s \) = system reliability = probability of survival.
- \( m \) = mean time between failures.
- \( t \) = time of test.
- \( \lambda \) = failure rate.

\[
\begin{align*}
I. \quad R_s &= \frac{1}{{m e^{-\frac{t}{m}}}} \\
II. \quad R_s &= e^{-\frac{m}{t}} \\
III. \quad R_s &= e^{-\frac{t}{m}} \\
IV. \quad R_s &= e^{-\frac{t}{2}}
\end{align*}
\]

A. I only  
B. II only  
C. III only  
D. IV only

89. A random sample of 100 bars of aluminum shows a tensile strength mean of 30,000 psi and a standard deviation of 3,000 psi. On the basis of this sample, what is the 95 percent confidence interval for the average tensile strength?

A. 30,000 ± 528 psi  
B. 30,000 ± 600 psi  
C. 30,000 ± 588 psi  
D. 30,000 ± 768 psi

90. A reliability test of 12 pumps is terminated at 1000 hours. There were 5 failures as follows, what is the median rank % for the 4th failure?

<table>
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<th>Failure</th>
<th>Time</th>
<th>Median Rank %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>170hr</td>
<td>5.61%</td>
</tr>
<tr>
<td>2</td>
<td>240hr</td>
<td>13.60%</td>
</tr>
<tr>
<td>3</td>
<td>500hr</td>
<td>21.60%</td>
</tr>
<tr>
<td>4</td>
<td>785hr</td>
<td>?</td>
</tr>
<tr>
<td>5</td>
<td>872hr</td>
<td>37.85%</td>
</tr>
</tbody>
</table>

A. 40.00%  
B. 29.84%  
C. 25.62%  
D. 24.48%

91. In 4 flips of a coin the probability of two heads and two tails (in any order) is:

A. 9/16  
B. 7/16  
C. 1/2  
D. 3/8
92. The hazard function is:
I. The probability of failure during a very small time interval, assuming a failure occurs before that time.
II. A function of constant failure rate only.
III. A function of increasing failure rate only.
IV. The ratio of the probability density function to the reliability function.
A. I only       B. II only       C. III only       D. IV only

93. Failure rate is calculated as a:
A. Probability of survival.       B. Average of secondary failures.
C. Reciprocal of MTBF.           D. Reciprocal of the loss function.

94. Which mathematical method provides a solution, has a time dimension and is solved numerically?
A. Strength and stress model.       B. Simulation model.
C. Analytic solution.         D. None of the above.

95. The distribution which has a mean equal to the variance is the:

96. Preventive maintenance is usually performed in the plant to ensure smooth transformation of raw materials to finished goods. A prime assumption for preventive maintenance action is:
A. Cost of failures are more than scheduled maintenance costs.
B. The part is in an increasing hazard rate period.
C. A constant hazard rate would result in no preventive maintenance.
D. The minimum point for total costs.
97. The basic maintainability requirements for a system or component is BEST determined via :
   A. Analysis of customer requirements.
   B. Analysis of test data.
   C. Analysis of field (actual) data.
   D. The compatibility of design engineering and maintainability engineering.

98. Given a system requirement of maintainability (MTTR) of 4.7 hours. There are 5 devices in series with the following individual failure rates and MTTR.

<table>
<thead>
<tr>
<th>Device</th>
<th>λ</th>
<th>MTTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device 1</td>
<td>27</td>
<td>3.2</td>
</tr>
<tr>
<td>Device 2</td>
<td>100</td>
<td>1.8</td>
</tr>
<tr>
<td>Device 3</td>
<td>250</td>
<td>7.5</td>
</tr>
<tr>
<td>Device 4</td>
<td>10</td>
<td>8.4</td>
</tr>
<tr>
<td>Device 5</td>
<td>5</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Determine the K factor.

A. 1.06  B. 0.82  C. 0.94  D. 0.87

99. Which of the following enters into the definitions of reliability ?
   Ⅰ. Mission time.
   Ⅱ. Stress level.
   Ⅲ. Conditional probability.

A. Ⅲ only.  B. Ⅰ and Ⅲ only.  C. Ⅰ and Ⅲ only.  D. Ⅰ, Ⅱ and Ⅲ.

100. Specifically, up-time ratio is a measure of :
101. The maintenance time constraint (t) is:
   A. The reciprocal of mission time (T).
   B. Determined by the exponential failure law and log tables.
   C. Usually prescribed as a requirement of the mission.
   D. The same as the maintainability increment (M delta).

102. If the average repair time for a system is 3 hours and the MTBMA is 122 hours, what is the operational availability?
   A. 0.975  B. 0.976  C. 0.982  D. 0.997

103. An appropriate preventive maintenance program can greatly increase the overall availability of a system because of:
   I. An increase in observed reliability.
   II. An improvement in product or system safety.
   III. A reduction in spare parts inventory.
   A. I only  B. II only  C. I and II only  D. I, II and III

104. Fault isolation is BEST facilitated by using which of the following?
   I. Built-in test equipment.
   II. Part interchangeability.
   III. Corrective maintenance.
   IV. Design simplification.
   A. I and II only  B. I, II and IV only  C. II, III and IV only  D. I, II, III and IV

105. The use of plug-in devices improves all of the following EXCEPT:
   A. Mean time to repair.
   B. Design reliability.
   C. Interchangeability.
   D. Fault isolation time.
106. Availability of a system is roughly the:
   A. Product of the individual subsystem availabilities.
   B. Sum of the individual system availabilities.
   C. The difference of the individual subsystem.
   D. The quotient of the individual subsystem availability.

107. Risk management includes which of the following?
   I. Integration of risk evaluation in all design phases.
   II. Knowledge and consideration of liability law.
   III. Adopting procedures, policies and practices to control risks.
   IV. Providing product labels and operator manuals where appropriate.
   A. I, II and III only  B. II and IV only  C. I, II and IV only  D. I, II, III and IV only

108. Product safety standards do NOT include:
   A. Product requirements laws passed by governments.
   B. Requirements for general, equipment and component safety.
   C. Performance requirements for products.
   D. Evaluation requirements for product safety testing.

109. Risk management activities do NOT include:
   A. Identifying the hazard.
   B. Rating the hazard.
   C. Controlling the hazard.
   D. Identifying similar hazards on other products.

110. Feedback channels for the planning, management and assessment of product safety should include:
   I. Both official and unofficial sources.
   II. Phone, fax, mail and questionnaire sources.
   III. Captured company process information.
   A. II only  B. I and III only  C. II and III only  D. I, II and III
111. Human will perform more reliably if:
   I. They understand what is required and why.
   II. The task is challenging and complex.
   III. Pressure is applied which penalizes failure.
   IV. There are incentives for quality.

   A. I and II only   B. I and III only   C. II and IV only   D. I and IV only

112. A go/no-go device is tested until it fails. If X is the number of tests to first failure with no wear out present, and the probability of success on each test is .99, then the probability that X is greater than 5 is:

   A. 0.9510   B. 0.9410   C. 0.9310   D. 0.9610

113. Internal testing sources of component reliability data are:

   A. Prototype and Reliability growth.   B. Industry and Public data.

114. Redundant components are used because:

   A. Reliability of parallel components is higher than the highest reliability component in parallel.
   B. Reliability of parallel components is higher than the lowest reliability component in parallel.
   C. Reliability of parallel components is lower than the highest reliability component in parallel.
   D. Reliability of parallel components is lower than the lowest reliability component in parallel.

115. A system has components connected in active parallel. At least n - 1 of the components must operate for the system to function properly. Suppose the time to failure of each component has an exponential distribution with the same failure rate \( \lambda \). The mean time to failure of this system is:

   A. \( \frac{2n - 1}{n(n - 1)} \lambda \)   B. \( \frac{1}{n - 1} \lambda \)
   C. \( 2n - 1 \lambda \)   D. \( \frac{(n - 1)n^2}{n} \lambda \)
116. In order to attain a high order of series reliability:
   A. The number of parts must be kept to a minimum.
   B. The number of parts must be increased.
   C. The number of parts must have a low failure variance.
   D. The number of parts is insignificant if each part has a reliability of 99 percent or more.

117. For equipment consisting of three components connected in series whose respective reliabilities are 0.95, 0.94, 0.96, which could be used to calculate total probability?

118. What is the failure rate of a system composed of three components, each of which can cause a system failure, and which have the following information?

<table>
<thead>
<tr>
<th>Component</th>
<th>Test Time</th>
<th>Failures</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1500 hours</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td>2200 hours</td>
<td>2</td>
</tr>
<tr>
<td>C</td>
<td>3000 hours</td>
<td>3</td>
</tr>
</tbody>
</table>

   A. 0.00192 f/hr.  B. 0.00258 f/hr.  C. 0.00913 f/hr.  D. 0.00671 f/hr.

119. The probability of an accident for the head event "H" given below is:
   A. 0.0700.
   B. 0.1125.
   C. 0.0689.
   D. 0.1100.
120. Which of the following FTA statements is NOT true?
   A. It provides corrective actions for component failures.
   B. It includes common mode failure effects.
   C. It indicates the critical path from system failure to component failure.
   D. It illustrates the overall system behavior.

121. The reliability engineer's ultimate goal in most organizations may be BEST expressed as:
   A. The reduction of warranty returns and improvement of test yields.
   B. The minimization of product failure rate during the constant failure rate period.
   C. The analysis and optimization of full life cycle cost impact.
   D. The identification and elimination of all failure modes.

122. What is the general use of an \( R \) chart?
   A. To determine if the process is in control.
   B. To determine if the process mean is in control.
   C. To determine if the process variance is in control.
   D. To determine the variance of the process.

123. Reliability Growth is:
   I. Often mathematically modeled with the Duane or AMSSA approaches.
   II. The existence of more than one means for accomplishing a given functions.
   III. Improvement of a reliability parameter by correcting deficiencies in the design.
   A. I and II only.  B. II only.  C. III only.  D. I and III only.

124. Total system effectiveness can be predicted during the conceptual or development design by considering three main elements of reliability. Which of the four elements does NOT apply?
   A. Inherent reliability.
   B. Manufacturing reliability.
   C. Test reliability.
   D. Use reliability.
125. The first phase in the operation life history of a population of product units is typically called:
   A. Debugging phase.   B. Wear out phase.
   C. Transition phase.   D. Chance failure phase.

126. It is reliability's job to see that all the tasks outlined in the reliability program are:
   A. Carried out by reliability engineers.
   B. Carried out by the department having the primary responsibility.
   C. Making sure that quality control does its job.
   D. Doing those jobs that the primary responsible departments are incapable of doing.

127. With respect to calculating a mission reliability, the time of the operating mission is:
   A. Always an important consideration.
   B. More important than the failure rate.
   C. Important only when discussing outer space exploration projects.
   D. Important only when assuming a constant failure rate.

128. Technical or functional relationships (transfer functions) are required to evaluate:
   I. The influence of accountable factors on system performance parameters.
   II. The influence of systems performance parameters on availability, dependability, and capability.
   III. System Effectiveness.
   IV. Expected total life cycle cost per mission.
   A. II only.   B. II and III only.   C. III and IV only.   D. I, II, III and IV.

129. All of the following activities would be appropriate during the design and development stage of a product's life cycle EXCEPT:
   A. Formalizing reliability requirements.   B. Measuring production reliability.
   C. Initiating the reliability growth testing.   D. Performing reliability analysis.
130. Successful reliability programs should address which of the following elements?
   I. Defining of the program and developing reliability goals and requirements.
   II. Designing for reliability and manufacturing feasibility.
   III. Assessing and measuring of reliability progress and ensuring reliable performance.
   IV. Providing for sequential and qualification testing plans in usage stage.

A. I and III only.  B. II and IV only.
C. I, II and III only.  D. I, II, III and IV.

131. An intelligent and good reliability program plan is one that:
   A. Retains flexibility by not formalizing reliability activities so that it cannot be tied down contractually.
   B. Defines in detail the complementary activities necessary for improving and assessing the reliability parameter.
   C. Delineates the responsibilities and interfaces in as general a manner as possible.
   D. Emphasize the planning activities over the control activities.

132. What is the probability of performing a repair within 10 hours, if the MTTR is 10 hours?
A. 0.368  B. 1.00  C. 0.632  D. 0.500

133. What type of failure is usually reduced by periodic overhaul and replacement of component parts?

134. The margin of safety in a design is BEST described by which of the following statements?
A. The ratio of the variance of the stress to the strength.
B. The ratio of the mean load to the mean strength.
C. The ratio of the difference between the mean strength and the mean load.
D. The mean load variance divided by the mean strength variance times 100.
135. In the House of Quality, the principal matrix shows the relationship between:
A. Specifications and Results. 
B. Quality Requirements and Quality Inspection. 
C. Wants and Hows. 
D. Reliability Results and Time.

136. The reliability manager or engineer attend and participate in:
A. The initial design review meetings.
B. Design review meetings where life-cycle-costs are discussed.
C. The later design review meetings that discuss production issues.
D. All of the design review meetings.

137. The reliability critical item list generally includes:
I. High cost components.
II. Single source or custom components.
III. Components whose failure can significantly affect safety.
A. I only  
B. III only  
C. I and III only  
D. I, II and III

138. Calculate the worst case minimum using the root-sum squared analysis for a 1000 μF capacitor using the following information.

<table>
<thead>
<tr>
<th>Parameters: Capacitance</th>
<th>Bias (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Neg.</td>
<td>Pos.</td>
</tr>
<tr>
<td>Initial Tolerance at 25°C</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Low Temp (-20°C)</td>
<td>20</td>
<td>-</td>
</tr>
<tr>
<td>High Temp (+80°C)</td>
<td>-</td>
<td>25</td>
</tr>
<tr>
<td>Other-Env'ts (Hard Vacuum)</td>
<td>15</td>
<td>-</td>
</tr>
<tr>
<td>Radiation (10KR, 10^{13} N/cm²)</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Aging</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

A. 470 μF  
B. 520 μF  
C. 480 μF  
D. 530 μF
139. A consideration for proper part selection is:
I. Parts application and specifications.
II. Selection, control and integration.
III. Derating.

A. I only  
B. I and III only  
C. II and III only  
D. I, II and III

140. Which of the following should be avoided in parts selection to enhance the design reliability?
A. Selection of standard parts.  
B. Selection of exotic technology parts.  
C. Selection of redundant parts.  
D. Selection of high reliability parts.

141. Concurrent engineering means:
A. Alternate designs being generated in parallel.  
B. Engineers working in tandem shifts to speed the process.  
C. An electrical engineering term.  
D. Use of inputs from all technical disciplines early and simultaneously.

142. The success of the FMEA is principally dependent on:
I. Good communication between the reliability engineer and the designer.  
II. Use of the correct form and definitions.  
III. Early determination of the reliability critical items.

A. I only  
B. II only  
C. III only  
D. II and III only

143. For complex electronics systems, the major contributor to repair time is generally:
A. Final checkout.  
B. Disassembly/reassembly.  
C. Remove/replace.  
D. Diagnosis.
144. Failure modes and effects analysis involves what activity?
A. The determination of the probability of failure in a specified period of time.
B. The expected number of failures in a given time interval.
C. The study of the physics of failure to determine exactly how a product fails and what causes the failure.
D. A study of the probability of success in a given time period.

145. The equation below represents
\[ C_p = \frac{USL - LSL}{6\sigma} \]
A. The limits for an X Bar control chart.  
B. The limits for a Range chart.  
C. The process capability adjusted for centering.  
D. The probability of meeting specification.

146. What is meant by "derating"?
I. The technique of using a part, component, or equipment under stress conditions considerably below rated values, to achieve a "reliability margin" in design.
II. The technique of using a part, component, or equipment under normal conditions to achieve a reliable product design.
III. The technique of using a part, component, or equipment below stress conditions to achieve a reliable product design.
A. I only  
B. III only  
C. I and III only  
D. I, II and III

147. The designer has certain tools for reliable design at his/her disposal. He/She can:
I. Simplify the design and minimize the number of parts without degrading performance.
II. Perform design reliability review by means of reliability analysis.
III. Apply component derating techniques.
IV. Reduce the elevated operating temperature of components.
A. I and III only  
B. II and IV only  
C. I, II and III only  
D. I, II, III and IV
148. Of the following, which is the MOST important reliability principle?
   A. Use only proven designs.
   B. Specify only high reliability components.
   C. Consider reliability early in the design phase.
   D. Use redundancy throughout the design.

149. The primary aim of sequential-life testing is to determine
   A. The probability density function of failures.
   B. The mean time between failures (MTBF).
   C. Whether a lot meets the reliability goal.
   D. Whether the stress-level variation is significant.

150. The department having the authority to sign all deviations pertaining to the design of the product is normally:
   A. Inspection.
   B. Manufacturing engineering.
   C. Design engineering.
   D. Contractual.
### Solutions:

|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 1 | A | 16 | C | 31 | B | 46 | C | 61 | A | 76 | A | 91 | D | 106 | A | 121 | C | 136 | D |
| 2 | B | 17 | B | 32 | C | 47 | B | 62 | C | 77 | B | 93 | C | 108 | C | 133 | D | 138 | A |
| 3 | A | 18 | A | 33 | B | 48 | A | 63 | C | 78 | B | 94 | B | 109 | A | 124 | C | 139 | D |
| 4 | D | 19 | D | 34 | D | 49 | D | 64 | D | 79 | A | 95 | B | 110 | D | 125 | A | 140 | B |
| 5 | A | 20 | A | 35 | B | 50 | A | 65 | A | 80 | D | 95 | A | 110 | D | 125 | A | 140 | B |
| 6 | D | 21 | C | 36 | C | 51 | C | 66 | B | 81 | D | 96 | A | 111 | D | 126 | B | 141 | D |
| 7 | C | 22 | C | 37 | B | 52 | B | 67 | D | 82 | B | 97 | A | 112 | A | 127 | A | 142 | A |
| 8 | B | 23 | D | 38 | A | 53 | A | 68 | A | 83 | A | 98 | B | 113 | A | 128 | D | 143 | D |
| 9 | C | 24 | A | 39 | D | 54 | D | 69 | B | 84 | C | 99 | D | 114 | A | 129 | A | 144 | C |
| 10 | B | 25 | B | 40 | C | 55 | A | 70 | C | 85 | A | 100 | D | 115 | A | 130 | C | 145 | C |
| 11 | C | 26 | A | 41 | B | 56 | B | 71 | B | 86 | B | 101 | C | 116 | A | 131 | B | 146 | A |
| 12 | A | 27 | A | 42 | D | 57 | C | 72 | C | 87 | C | 102 | B | 117 | C | 132 | C | 147 | D |
| 13 | A | 28 | B | 43 | D | 58 | D | 73 | D | 88 | C | 103 | A | 118 | B | 133 | B | 148 | C |
| 14 | D | 29 | D | 44 | D | 59 | A | 74 | C | 89 | C | 104 | B | 119 | C | 134 | C | 149 | C |
| 15 | D | 30 | B | 45 | B | 60 | B | 75 | B | 90 | B | 105 | B | 120 | A | 135 | C | 150 | C |