**Chapter 4 Supplement: Reliability**

**Practice Problems**

**MULTIPLE CHOICE**

Meacham industry produces a unit that requires three separate components to function together. Each of the three components has a reliability level of 96%. However, the overall requirement for the three separate components to function together is 98%.

1. Given the current setup, what is the actual overall reliability of these three components?

|  |  |  |
| --- | --- | --- |
| a. | .9998 |  |
| b. | .9800 |  |
| c. | .9600 |  |
| d. | .8847 |  |

ANS: D PTS: 1 DIF: Easy

2. If the overall reliability of the three components functioning together is 98%, what should the reliability of each individual component be in order to achieve that overall level of reliability?

|  |  |
| --- | --- |
| a. | .8847 |
| b. | .9436 |
| c. | .9933 |
| d. | .9999 |

ANS: C PTS: 1 DIF: Medium

3. If Meacham industry adds one backup component (with the same reliability of 96%) to component one, what would be the overall reliability of the system?

|  |  |
| --- | --- |
| a. | .9021 |
| b. | .9201 |
| c. | .9569 |
| d. | .9824 |

ANS: B PTS: 1 DIF: Medium

4. If Meacham industry adds one component backup (same reliability of 96%) to both components one and two, what would be the overall reliability of the system?

|  |  |
| --- | --- |
| a. | .9021 |
| b. | .9201 |
| c. | .9569 |
| d. | .9824 |

ANS: C PTS: 1 DIF: Medium

5. If Meacham industry adds one backup component (with same reliability of 96%) to all three components, what would be the overall reliability system?

|  |  |
| --- | --- |
| a. | .9021 |
| b. | .9202 |
| c. | .9824 |
| d. | .9952 |

ANS: D PTS: 1 DIF: Medium

Cousteau Adventures is building an underwater resort. The life-support system consists of five components, each of which has a reliability of 97.5%. However, the overall required reliability because of safety issues must be 99.99%.

6. Currently, with the five components in place, what is the overall reliability of the system?

|  |  |
| --- | --- |
| a. | .8634 |
| b. | .8811 |
| c. | .9024 |
| d. | .9245 |

ANS: B PTS: 1 DIF: Easy

7. If Cousteau Adventures adds one identical backup to Component 1, what would be the reliability of the overall system?

|  |  |
| --- | --- |
| a. | .8821 |
| b. | .9031 |
| c. | .9256 |
| d. | .9346 |

ANS: B PTS: 1 DIF: Medium

8. If Cousteau Adventures adds one identical backup to Components 1 and 2, what would be the reliability of the overall system?

|  |  |
| --- | --- |
| a. | .9257 |
| b. | .9333 |
| c. | .9488 |
| d. | .9674 |

ANS: A PTS: 1 DIF: Medium

9. If Cousteau Adventures adds one identical backup to Components 1, 2, and 3, what would be the reliability of the overall system?

|  |  |
| --- | --- |
| a. | .9031 |
| b. | .9488 |
| c. | .9674 |
| d. | .9844 |

ANS: B PTS: 1 DIF: Medium

10. If Cousteau Adventures adds one identical backup to Components 1, 2, 3, and 4, what would be the reliability of the overall system?

|  |  |
| --- | --- |
| a. | .9031 |
| b. | .9488 |
| c. | .9674 |
| d. | .9726 |

ANS: D PTS: 1 DIF: Medium

11. If Cousteau Adventures adds one identical backup to all five components, what would be the reliability of the overall system?

|  |  |
| --- | --- |
| a. | .9802 |
| b. | .9864 |
| c. | .9969 |
| d. | .9998 |

ANS: C PTS: 1 DIF: Medium

12. Currently, what would the reliability of each of the five components have to be in order to achieve the required reliability of the system?

|  |  |
| --- | --- |
| a. | .99966 |
| b. | .99989 |
| c. | .99998 |
| d. | 1.00000 |

ANS: C PTS: 1 DIF: Medium

Consolidated Industries produces communication equipment. One group of products is designed to function in extremely cold weather. The statistics for Mean Time Between Failure (MBTF) and the Mean Time To Repair (MTTR) these communication items are given below.

|  |  |  |
| --- | --- | --- |
|  | MTBF | MTTR |
| A | 700 | 3 |
| B | 800 | 5 |
| C | 1000 | 10 |
| D | 900 | 8 |

13. What is the availability of product A?

|  |  |
| --- | --- |
| a. | 0.9957 |
| b. | 0.9938 |
| c. | 0.9901 |
| d. | 0.9912 |

ANS: A PTS: 1 DIF: Easy

14. What is the availability of product B?

|  |  |
| --- | --- |
| a. | 0.9957 |
| b. | 0.9938 |
| c. | 0.9901 |
| d. | 0.9912 |

ANS: B PTS: 1 DIF: Easy

15. What is the availability of product C?

|  |  |
| --- | --- |
| a. | 0.9957 |
| b. | 0.9938 |
| c. | 0.9901 |
| d. | 0.9912 |

ANS: C PTS: 1 DIF: Easy

16. What is the availability of product D?

|  |  |
| --- | --- |
| a. | 0.9957 |
| b. | 0.9938 |
| c. | 0.9901 |
| d. | 0.9912 |

ANS: D PTS: 1 DIF: Easy

17. Which of the four products would you select?

|  |  |
| --- | --- |
| a. | A |
| b. | B |
| c. | C |
| d. | D |

ANS: A PTS: 1 DIF: Easy

Nano Space Tech produces ultra-small satellites. All of the satellites use the same « bus » design. Critical to the operation of the small satellite is its control system. In order for the control system to function, all five components must operate successfully. Along with the blessing of the individual reliability of five components.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 1 | 2 | 3 | 4 | 5 |
| 0.93 | 0.99 | 0.98 | 0.975 | 0.96 |

18. Given these five components, what would be the overall reliability of the control system?

|  |  |
| --- | --- |
| a. | .8255 |
| b. | .8445 |
| c. | .8656 |
| d. | .8845 |

ANS: B PTS: 1 DIF: Easy

19. If the five components were replaced by components with identical reliabilities, what would the reliability have to be in order to achieve an overall system reliability of 99.9%?

|  |  |
| --- | --- |
| a. | .9944 |
| b. | .9968 |
| c. | .9990 |
| d. | .9998 |

ANS: D PTS: 1 DIF: Medium

20. What would be the overall reliability of the original system if Component 1 received one backup?

|  |  |
| --- | --- |
| a. | .8876 |
| b. | .8976 |
| c. | .9037 |
| d. | .9256 |

ANS: C PTS: 1 DIF: Medium

21. What would be the overall reliability of the original system if Components 1 and 2 each received one backup?

|  |  |
| --- | --- |
| a. | .8978 |
| b. | .9054 |
| c. | .9127 |
| d. | .9503 |

ANS: C PTS: 1 DIF: Medium

22. What would be the overall reliability of the original system Components 1, 2, and 3, if each received one backup?

|  |  |
| --- | --- |
| a. | .9234 |
| b. | .9456 |
| c. | .9309 |
| d. | .9826 |

ANS: C PTS: 1 DIF: Medium

23. What would be the overall reliability of the original system Components 1, 2, 3, and 4, if each received one backup?

|  |  |
| --- | --- |
| a. | .9456 |
| b. | .9503 |
| c. | .9786 |
| d. | .9542 |

ANS: D PTS: 1 DIF: Medium

24. What would be the overall reliability of the original system if all of the five components each received one backup?

|  |  |
| --- | --- |
| a. | .9678 |
| b. | .9840 |
| c. | .9924 |
| d. | .9998 |

ANS: C PTS: 1 DIF: Medium

Xebec Technologies’ purchasing department is examining four suppliers that provide an important element for one of Xebec’s mainline product. This element requires three components. Xebec has carefully analyzed the four suppliers to determine the reliability of each of the three components. The data is listed below.

|  |  |  |  |
| --- | --- | --- | --- |
| Supplier | C1 | C2 | C3 |
| Allen | 0.98 | 0.97 | 0.98 |
| Bales | 0.96 | 0.96 | 0.97 |
| Dumont | 0.98 | 0.93 | 0.99 |
| Sequant | 0.96 | 0.96 | 0.99 |

25. What is the overall reliability of Allen’s element?

|  |  |
| --- | --- |
| a. | .9234 |
| b. | .9316 |
| c. | .9453 |
| d. | .9522 |

ANS: B PTS: 1 DIF: Easy

26. What is the overall reliability of Bale’s element?

|  |  |
| --- | --- |
| a. | .8940 |
| b. | .9124 |
| c. | .9453 |
| d. | .9522 |

ANS: A PTS: 1 DIF: Easy

27. What is the overall reliability of Dumont’s element?

|  |  |
| --- | --- |
| a. | .8940 |
| b. | .9023 |
| c. | .9144 |
| d. | .9256 |

ANS: B PTS: 1 DIF: Easy

28. What is the overall reliability of Sequant’s element?

|  |  |
| --- | --- |
| a. | .8940 |
| b. | .9023 |
| c. | .9124 |
| d. | .9316 |

ANS: C PTS: 1 DIF: Easy

29. In terms of overall reliability which supplier is best?

|  |  |
| --- | --- |
| a. | Allen |
| b. | Bales |
| c. | Dumont |
| d. | Sequant |

ANS: A PTS: 1 DIF: Medium

30. Great Eastern Aerospace is developing a radar that has a required reliability of 99.99%. A key element is provided by each of the four suppliers with a different level of reliability and a different cost. The data is provided below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Supplier W | Supplier X | Supplier Y | Supplier Z |
| Reliability | 99% | 97% | 96% | 94% |
| Cost | $3,000 | $2,000 | $1,500 | $500 |

What number of backups for each of the four components would produce the lowest total cost for Great Eastern Aerospace?

|  |  |
| --- | --- |
| a. | one unit from Supplier W |
| b. | two units from Supplier X |
| c. | three units from Supplier Y |
| d. | four units from Supplier Z |

ANS: D PTS: 1 DIF: Medium

McMann Manufacturing needs an electronic control panel for their commercial printer. McMann outsourced the design of the electronic control panel to three companies. McMann was extremely disappointed in the performance of all three subcontractors. The designs of all three subcontractors called for four components. It was determined that the reliability of each of the four components for the three subcontractors was fairly low—see the data below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | C-1 | C-2 | C-3 | C-4 |
| Chiang | 0.92 | 0.89 | 0.94 | 0.98 |
| Althena | 0.88 | 0.93 | 0.93 | 0.97 |
| MicroTech | 0.88 | 0.96 | 0.96 | 0.96 |

31. What is the overall reliability of the best performing subcontractor?

|  |  |
| --- | --- |
| a. | .7383 |
| b. | .7456 |
| c. | .7786 |
| d. | .8896 |

ANS: C PTS: 1 DIF: Medium

32. The three subcontractors offered to redesign the control board with three backups for each of the four components. If the overall reliability is required to be 99.99%. What was the outcome?

|  |  |
| --- | --- |
| a. | all three subcontractors passed |
| b. | only Microtech passed |
| c. | only Microtech and Athena passed |
| d. | all three subcontractors failed |

ANS: D PTS: 1 DIF: Medium

A game controller has two components. Under the current redesign, Component 1 has a reliability of 98% while Component 2 has a reliability of 97%. This redesign requires that if there are any backups, there must be the same number of backups for both components.

33. If the required reliability level is 99.8%, at least how many backup components should be designed into the system?

|  |  |
| --- | --- |
| a. | 1 |
| b. | 2 |
| c. | 3 |
| d. | 4 |

ANS: A PTS: 1 DIF: Medium

34. If the required reliability factor is increased to 99.999%, at least how many backup components should be designed into the system?

|  |  |
| --- | --- |
| a. | 1 |
| b. | 2 |
| c. | 3 |
| d. | 4 |

ANS: B PTS: 1 DIF: Medium

The U.S. Air Force is reviewing data on three airborne radar systems. They have collected reliability and repair time data for the three radars. The data is provided below.

|  |  |  |
| --- | --- | --- |
|  | MTBF | MTTR |
| Northrop-Grumman | 700 | 36 |
| Raytheon | 900 | 48 |
| BAE Systems | 1200 | 60 |

The Air Force has a required availability 0f 98%. Currently, none of the three manufacturers can improve their Mean Time Between Failure (MTBF), but they might improve the Mean Time To Repair (MTTR).

35. What would the MTTR have to be for Northrop-Grumman to meet the required 98% availability requirement?

|  |  |
| --- | --- |
| a. | 9 |
| b. | 12 |
| c. | 14 |
| d. | 24 |

ANS: C PTS: 1 DIF: Medium

36. What would the MTTR have to be for Raytheon to meet the required 98% availability requirement?

|  |  |
| --- | --- |
| a. | 16 |
| b. | 17 |
| c. | 18 |
| d. | 19 |

ANS: C PTS: 1 DIF: Medium

37. What would the MTTR have to be for BAE Systems to meet the required 98% availability requirement?

|  |  |
| --- | --- |
| a. | 18 |
| b. | 20 |
| c. | 22 |
| d. | 24 |

ANS: D PTS: 1 DIF: Medium

38. The three manufacturers reviewed and found that they were unable to change the Mean Time To Repair (MTTR), but they believe that they could extend the Mean Time Between Failure (MTBF). What would Northrop Grumman have to increase the Mean Time Between Failure (MTBF) to in order to achieve a 98% availability?

|  |  |
| --- | --- |
| a. | 1390 |
| b. | 2674 |
| c. | 1764 |
| d. | 3214 |

ANS: C PTS: 1 DIF: Hard

39. The three manufacturers reviewed and found that they were unable to change the Mean Time To Repair (MTTR), but they believe that they could extend the Mean Time Between Failure (MTBF). What would Raytheon have to increase the Mean Time Between Failure (MTBF) to in order to achieve a 98% availability?

|  |  |
| --- | --- |
| a. | 2352 |
| b. | 4128 |
| c. | 4436 |
| d. | 5124 |

ANS: A PTS: 1 DIF: Hard

40. The three manufacturers reviewed and found that they were unable to change the Mean Time To Repair (MTTR), but they believe that they could extend the Mean Time Between Failure (MTBF). What would BAE Systems have to increase the Mean Time Between Failure (MTBF) to in order to achieve a 98% availability?

|  |  |
| --- | --- |
| a. | 3852 |
| b. | 4128 |
| c. | 4586 |
| d. | 2940 |

ANS: D PTS: 1 DIF: Hard

NASA is planning a space probe that would orbit Jupiter. Due to some recent design changes, the space probe has a lower weight and therefore could carry a small probe that could enter the atmosphere of Jupiter. The issue that arises is that Jupiter is surrounded by an intense belt of radiation. The probe would have to be designed with computer chips that have not been « radiation hardened », which would make them able to operate in such a difficult environment. The chips that they could use have the following probability of functioning during the entry phase and to Jupiter’s atmosphere.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Chip | 1 | 2 | 3 | 4 | 5 |
| Probability of Working | 0.86 | 0.88 | 0.94 | 0.97 | 0.98 |

All five chips would have to function in unison in order for the program to be able to deliver its data. Although the probe can’t use « radiation hardened chips », it could provide backups for the chips.

41. What would be the probe’s probability of success if the probe uses only one set of each type of chips?

|  |  |
| --- | --- |
| a. | .5525 |
| b. | .6048 |
| c. | .6762 |
| d. | .7854 |

ANS: C PTS: 1 DIF: Easy

42. What would be the probe’s probability of success if the probe uses only one backup for each type of chips?

|  |  |
| --- | --- |
| a. | .7854 |
| b. | .8864 |
| c. | .9616 |
| d. | .9898 |

ANS: C PTS: 1 DIF: Medium

43. What would be the probe’s probability of success if the probe uses only 2 more backups for Chip Type 1?

|  |  |
| --- | --- |
| a. | .6876 |
| b. | .7842 |
| c. | .8456 |
| d. | .9088 |

ANS: B PTS: 1 DIF: Hard

44. What would be the probe’s probability of success if the probe uses only 2 backups for Chip Type 1 and one backup for Chip Type 2?

|  |  |
| --- | --- |
| a. | .8088 |
| b. | .8366 |
| c. | .8783 |
| d. | .9024 |

ANS: C PTS: 1 DIF: Hard

Vision Movie Theater Chain is considering building an additional 100 theaters. One of their prime issues is securing the appropriate commercial air conditioner for the theaters. After putting out a request for proposal (RFP), Vision received information from four suppliers. The data is listed below.

|  |  |  |
| --- | --- | --- |
|  | MTBF | MTTR |
| Tranor | 5000 | 350 |
| Lennox | 5500 | 400 |
| LG | 8000 | 500 |
| Frigidare | 9000 | 400 |

45. What is the availability for Tranor?

|  |  |
| --- | --- |
| a. | .9012 |
| b. | .9238 |
| c. | .9346 |
| d. | .9568 |

ANS: C PTS: 1 DIF: Easy

46. What is the availability for LG?

|  |  |
| --- | --- |
| a. | .9167 |
| b. | .9322 |
| c. | .9412 |
| d. | .9642 |

ANS: C PTS: 1 DIF: Easy

47. Assume that Vision Movie Theaters requires an availability factor of 98% and that Tranor has decided that its could reduce its Mean Time To Repair value. What would the MTTR for Trainor have to be in order to provide an availability rating of 98%?

|  |  |
| --- | --- |
| a. | 94 |
| b. | 102 |
| c. | 112 |
| d. | 206 |

ANS: B PTS: 1 DIF: Medium

48. Assume that Vision Movie Theaters requires an availability factor of 98% and that LG has decided that its could reduce its Mean Time To Repair value. What would the MTTR for LG have to be in order to provide an availability rating of 98%?

|  |  |
| --- | --- |
| a. | 163 |
| b. | 180 |
| c. | 204 |
| d. | 260 |

ANS: A PTS: 1 DIF: Medium

49. All four commercial air conditioner manufacturers have gone to Vision Movie Theaters and stated that they can lower their Mean Time To Repair (MTTR) values so that they can achieve a 98% availability rating. However, each has specified that it would result in a fee in order to lower the Mean Time To Repair (MTTR). The values for those fees ($/Hour Reduction) are given below.

|  |  |
| --- | --- |
|  | Cost of Reducing MTTR by Hour |
| Tranor | $600 |
| Lennox | $450 |
| LG | $150 |
| Frigidare | $175 |

What fee would Frigidaire charge Vision Movie Theaters?

|  |  |
| --- | --- |
| a. | $60,000 |
| b. | $49,500 |
| c. | $24,000 |
| d. | $37,857 |

ANS: D PTS: 1 DIF: Hard

50. All four commercial air conditioner manufacturers have going to Vision Movie Theaters and stated that they can lower their Mean Time to Repair (MTTR) values so that they can achieve a 98% availability rating. However, each has specified that it would result in a fee in order to lower the Mean Time to Repair (MTTR). The values for those fees ($/Hour Reduction) are given below.

|  |  |
| --- | --- |
|  | Cost of Reducing MTTR by Hour |
| Tranor | $600 |
| Lennox | $450 |
| LG | $150 |
| Frigidare | $175 |

What fee would LG charge Lennox Theaters?

|  |  |
| --- | --- |
| a. | $60,000 |
| b. | $50,510 |
| c. | $24,000 |
| d. | $31,500 |

ANS: B PTS: 1 DIF: Hard