From equation 3-39, the approximate variance of R is

$$V(R) = \sigma_R^2 \simeq \left(\frac{\partial R}{\partial R_1}\right)^2 \sigma_{R_1}^2 + \left(\frac{\partial R}{\partial R_2}\right)^2 \sigma_{R_2}^2$$

$$\simeq (0.5102)^2(0.5) + (0.0812)^2(1)$$

$$\simeq 0.1367\Omega^2$$

The standard deviation of R is $\sigma_R \simeq 0.3698$ ohms.

EXERCISES FOR SECTION 3-12

3-137. If X_1 and X_2 are independent random variables with $E(X_1) = 2$, $E(X_2) = 5$, $V(X_1) = 2$, and $V(X_2) = 10$, determine the following.

(a) $E(3X_1 + 5X_2)$ (b) $V(3X_1 + 5X_2)$

3-138. If X_1, X_2, and X_3 are independent random variables with $E(X_1) = 4$, $E(X_2) = 3$, $E(X_3) = 2$, $V(X_1) = 1$, $V(X_2) = 5$, and $V(X_3) = 2$, determine the following.

(a) $E(2X_1 + 0.5X_2 - 3X_3)$ (b) $V(2X_1 + 0.5X_2 - 3X_3)$

3-139. If X_1 and X_2 are independent random variables with $\mu_1 = 6$, $\mu_2 = 1$, $\sigma_1 = 2$, $\sigma_2 = 4$, and $Y = 4X_1 - 2X_2$, determine the following.

(a) $E(Y)$ (b) $V(Y)$ (c) $E(2Y)$ (d) $V(2Y)$

3-140. If X_1, X_2, and X_3 are independent random variables with $\mu_1 = 1.2$, $\mu_2 = 0.8$, $\mu_3 = 0.5$, $\sigma_1 = 1$, $\sigma_2 = 0.25$, $\sigma_3 = 2.2$, and $Y = 2.5X_1 - 0.5X_2 + 1.5X_3$, determine the following.

(a) $E(Y)$ (b) $V(Y)$ (c) $E(-3Y)$ (d) $V(-3Y)$

3-141. Consider the variables defined in Exercise 3-137. Assume that X_1 and X_2 are normal random variables. Compute the following probabilities.

(a) $P(3X_1 + 5X_2 \le 50)$
(b) $P(25 \le 3X_1 + 5X_2 \le 37)$
(c) $P(14.63 \le 3X_1 + 5X_2 \le 47.37)$

3-142. Consider the variables defined in Exercise 3-138. Assume that X_1, X_2, and X_3 are normal random variables. Compute the following probabilities.

(a) $P(2X_1 + 0.5X_2 - 3X_3 > 2.0)$
(b) $P(1.3 \le 2X_1 + 0.5X_2 - 3X_3 \le 8.3)$

3-143. A plastic casing for a magnetic disk is composed of two halves. The thickness of each half is normally distributed with a mean of 1.5 millimeters and a standard deviation of 0.1 millimeter and the halves are independent.

(a) Determine the mean and standard deviation of the total thickness of the two halves.
(b) What is the probability that the total thickness exceeds 3.3 millimeters?

3-144. The width of a casing for a door is normally distributed with a mean of 24 inches and a standard deviation of 1/8 inch. The width of a door is normally distributed with a mean of 23 and 7/8 inches and a standard deviation of 1/16 inch. Assume independence.

(a) Determine the mean and standard deviation of the difference between the width of the casing and the width of the door.
(b) What is the probability that the width of the casing minus the width of the door exceeds 1/4 inch?
(c) What is the probability that the door does not fit in the casing?

3-145. A U-shaped assembly is to be formed from the three parts A, B, and C. The picture is shown in Fig. 3-43. The length of A is normally distributed with a mean of 10 millimeters and a standard deviation of 0.1 millimeter. The thickness of part B is normally distributed with a mean of 2 millimeters and a standard deviation of 0.05 millimeter. The thickness of C is normally distributed with mean 2 millimeters and a standard deviation of 0.10 millimeter. Assume that all dimensions are independent.

(a) Determine the mean and standard deviation of the length of the gap D.
(b) What is the probability that the gap D is less than 5.9 millimeters?

3-146. Consider the random variables defined in Exercise 3-137. Assume that the random variables are not independent and have $\text{Cov}(X_1, X_2) = 2$. Compute the mean and variance of the expression $3X_1 + 5X_2$.

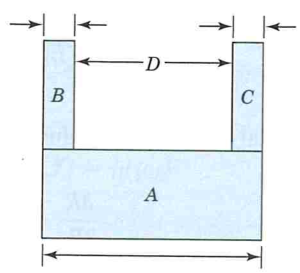


Figure 3-43 Figure for Exercise 3-145.

3-147. Consider the random variables defined in exercise 3-139. Assume that the random variables are not independent and have $\text{Cov}(X_1, X_2) = 5$. Compute the mean and variance of Y.

3-148. Consider Example 3-42. If the two resistors are connected in series rather than parallel, $R = R_1 + R_2$. Assume that the two resistors are independent. Compute the mean and variance of R.

3-149. Let X have a mean 20 and variance 9. Define $Y = 2X^2$. Compute the mean, ~~and variance of Y.~~ Use propagation of error to estimate the mean and variance of Y.

3-150. Let X have a mean 100 and variance 25. Define $Y = X^2 + 2X + 1$. Compute the mean and variance of Y.

3-151. Consider Example 3-41. Let the current have mean of 40 amperes and a standard deviation of 0.5 amperes. If the electrical circuit has a resistance of 100 ohms, compute the mean and variance of P.

3-152. Consider the equation for the period T of a pendulum given in Section 3-12.3. Suppose that the length L is random variable with mean 30 feet and standard deviation 0.02 feet. Compute the mean and variance of T.

3-153. Consider the equation for the acceleration due to gravity, G, given in Section 3-12.3. Suppose that $E(T) = 5.2$ seconds and $V(T) = 0.0004$ square seconds. Compute the mean and variance of G.

3-154. Consider X_1 and X_2 given in Exercise 3-137. Define $Y = X_1X_2$. Compute the mean and variance of Y.

3-155. Consider X_1, X_2, and X_3 given in Exercise 3-138. Define $Y = X_1X_2X_3$. Compute the mean and variance of Y.

3-156. The volume V of a cube is defined as the product of the length, L, the width, W, and the height, H. Assume that each of these dimensions is a random variable with mean 2 inches and standard deviation 0.1 inches. Assume independence and compute the mean and variance of V.

3-13 RANDOM SAMPLES, STATISTICS, AND THE CENTRAL LIMIT THEOREM

Previously in this chapter it was mentioned that data are the observed values of random variables obtained from replicates of a random experiment. Let the random variables that represent the observations from the n replicates be denoted by $X_1, X_2, \ldots, X_n$. Because the replicates are identical, each random variable has the same distribution. Furthermore, the random variables are often assumed to be independent. That is, the results from some replicates do not affect the results from others. Throughout the remainder of the book, a common model is that data are observations from independent random variables with the same distribution. That is, data are observations from independent replicates of a random experiment. This model is used so frequently that we provide a definition.

Random Sample

> Independent random variables $X_1, X_2, \ldots, X_n$ with the same distribution are called a **random sample.**

The term "random sample" stems from the historical use of statistical methods. Suppose that from a large population of objects, a sample of n objects is selected randomly. Here, randomly means that each subset of size n is equally likely to be selected. If the number of objects in the population is much larger than n, the random variables $X_1, X_2, \ldots, X_n$ that represent the observations from the sample can be shown to be approximately independent random variables with the same distribution. Consequently, independent random variables with the same distribution are referred to as a random sample.

EXAMPLE 3-43

In Example 2-1 in Chapter 2, the average tensile strength of eight rubber O-rings was 1055 psi. Two obvious questions are the following: What can we conclude about the average tensile strength of future O-rings? How wrong might we be if we concluded that the average tensile strength of this future population of O-rings is 1055?

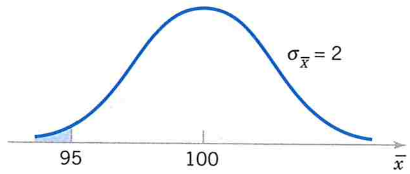


Figure 3-43 Probability density function of average resistance.

Note that the sampling distribution of $\overline{X}$ is approximately normal, with mean $\mu_{\overline{X}} = 100\ \Omega$ and a standard deviation of

$$\sigma_{\overline{X}} = \frac{\sigma}{\sqrt{n}} = \frac{10}{\sqrt{25}} = 2$$

Therefore, the desired probability corresponds to the shaded area in Fig. 3-43. Standardizing the point $\overline{X} = 95$ in Fig. 3-43, we find that

$$z = \frac{95 - 100}{2} = -2.5$$

and therefore,

$$P(\overline{X} < 95) = P(Z < -2.5) = 0.0062$$

EXERCISES FOR SECTION 3-13

3-157. Given that X is normally distributed with mean 100 and standard deviation 9, compute the following for $n = 16$.

(a) Mean and variance of $\overline{X}$.

(b) $P(\overline{X} \le 98)$

(c) $P(\overline{X} > 103)$

(d) $P(96 \le \overline{X} \le 102)$

3-158. Given that X is normally distributed with mean 50 and standard deviation 4, compute the following for $n = 25$.

(a) Mean and variance of $\overline{X}$.

(b) $P(\overline{X} \le 49)$

(c) $P(\overline{X} > 52)$

(d) $P(49 \le \overline{X} \le 51.5)$

3-159. Assume a sample of 40 observations are drawn from a population with mean 20 and variance 2. Compute the following.

(a) Mean and variance of $\overline{X}$.

(c) $P(\overline{X} \le 19)$

(d) $P(\overline{X} > 22)$

(e) $P(19 \le \overline{X} \le 21.5)$

3-160. Intravenous fluid bags are filled by an automated filling machine. Assume that the fill volumes of the bags are independent, normal random variables with a standard deviation of 0.08 fluid ounces.

(a) What is the standard deviation of the average fill volume of 20 bags?

(b) If the mean fill volume of the machine is 6.16 ounces, what is the probability that the average fill volume of 20 bags is below 5.95 ounces?

(c) What should the mean fill volume equal in order that the probability that the average of 20 bags is below 6 ounces is 0.001?

3-161. The photoresist thickness in semiconductor manufacturing has a mean of 10 micrometers and a standard deviation of 1 micrometer. Assume that the thickness is normally distributed and that the thicknesses of different wafers are independent.

(a) Determine the probability that the average thickness of 10 wafers is either greater than 11 or less than 9 micrometers.

(b) Determine the number of wafers that need to be measured such that the probability that the average thickness exceeds 11 micrometers is 0.01.

3-162. The time to complete a manual task in a manufacturing operation is considered a normally distributed random variable with mean of 0.50 minute and a standard deviation of 0.05 minute. Find the probability that the average time to complete the manual task, after 49 repetitions, is less than 0.465 minute.

3-163. A synthetic fiber used in manufacturing carpet has tensile strength that is normally distributed with mean 75.5 psi and standard deviation 3.5 psi. Find the probability that a random sample of $n = 6$ fiber specimens will have sample mean tensile strength that exceeds 75.75 psi.

3-164. The compressive strength of concrete has a mean of 2500 psi and a standard deviation of 50 psi. Find the probability that a random sample of $n = 5$ specimens will have a sample mean strength that falls in the interval from 2490 psi to 2510 psi.

3-165. The amount of time that a customer spends waiting at an airport check-in counter is a random variable with mean 8.2 minutes and standard deviation 1.5 minutes. Suppose that a random sample of $n = 49$ customers is observed. Find the probability that the average time waiting in line for these customers is

(a) Less than 8 minutes
(b) Between 8 and 9 minutes
(c) Less than 7.5 minutes

3-166. Suppose that X has the following discrete distribution

$$f(x) = \begin{cases} \frac{1}{3}, & x = 1, 2, 3 \\ 0, & \text{otherwise} \end{cases}$$

A random sample of $n = 36$ is selected from this population. Approximate the probability that the sample mean is greater than 2.1 but less than 2.5.

3-167. The viscosity of a fluid can be measured in an experiment by dropping a small ball into a calibrated tube containing the fluid and observing the random variable X, the time it takes for the ball to drop the measured distance. Assume that X is normally distributed with a mean of 20 seconds and a standard deviation of 0.5 second for a particular type of liquid.

(a) What is the standard deviation of the average time of 40 experiments?
(b) What is the probability that the average time of 40 experiments will exceed 20.1 seconds?
(c) Suppose the experiment is repeated only 20 times. What is the probability that the average value of X will exceed 20.1 seconds?
(d) Is the probability computed in part (b) greater than or less than the probability computed in part (c)? Explain why this inequality occurs.

3-168. A random sample of $n = 9$ structural elements is tested for compressive strength. We know that the true mean compressive strength $\mu = 5500$ psi and the standard deviation is $\sigma = 100$ psi. Find the probability that the sample mean compressive strength exceeds 4985 psi.

SUPPLEMENTAL EXERCISES

3-169. Suppose that $f(x) = e^{-x}$ for $0 < x$ and $f(x) = 0$ for $x < 0$. Determine the following probabilities.

(a) $P(X \leq 1.5)$ (b) $P(X < 1.5)$ (c) $P(1.5 < X < 3)$
(d) $P(X = 3)$ (e) $P(X > 3)$

3-170. Suppose that $f(x) = e^{-x/2}$ for $0 < x$ and $f(x) = 0$ for $x < 0$.

(a) Determine x such that $P(x < X) = 0.20$.
(b) Determine x such that $P(X \leq x) = 0.75$.

3-171. The random variable X has the following probability distribution.

x	2	3	5	8
Probability	0.2	0.4	0.3	0.1

Determine the following.

(a) $P(X \leq 3)$ (b) $P(X > 2.5)$ (c) $P(2.7 < X < 5.1)$
(d) $E(X)$ (e) $V(X)$

3-172. A driveshaft will suffer fatigue failure with a mean time-to-failure of 40,000 hours of use. If it is known that the probability of failure before 36,000 hours is 0.04 and that the distribution governing time-to-failure is a normal distribution, what is the standard deviation of the time-to-failure distribution?

3-173. A standard fluorescent tube has a life length that is normally distributed with a mean of 7000 hours and a standard deviation of 1000 hours. A competitor has developed a compact fluorescent lighting system that will fit into incandescent sockets. It claims that a new compact tube has a normally distributed life length with a mean of 7500 hours and a standard deviation of 1200 hours. Which fluorescent tube is more likely to have a life length greater than 9000 hours? Justify your answer.

3-174. The average life of a certain type of compressor is 10 years with a standard deviation of 1 year. The manufacturer replaces free all compressors that fail while under guarantee. The manufacturer is willing to replace 3% of all compressors sold. For how many years should the guarantee be in effect? Assume a normal distribution.

3-175. The probability that a call to an emergency help line is answered in less than 15 seconds is 0.85. Assume that all calls are independent.

(a) What is the probability that exactly 7 of 10 calls are answered within 15 seconds?
(b) What is the probability that at least 16 of 20 calls are answered in less than 15 seconds?
(c) For 50 calls, what is the mean number of calls that are answered in less than 15 seconds?
(d) Repeat parts (a)–(c) using the normal approximation.

3-176. The number of messages sent to a computer bulletin board is a Poisson random variable with a mean of five messages per hour.

(a) What is the probability that 5 messages are received in 1 hour?

(b) What is the probability that 10 messages are received in 1.5 hours?

(c) What is the probability that fewer than 2 messages are received in $\frac{1}{2}$ hour?

3-177. Continuation of Exercise 3-176. Let Y be the random variable defined as the time between messages arriving to the computer bulletin board.

(a) What is the distribution of Y? What is the mean of Y?

(b) What is the probability that the time between messages exceeds 15 minutes?

(c) What is the probability that the time between messages is less than 5 minutes?

(d) Given that 10 minutes has passed without a message arriving, what is the probability that there will not be a message in the next 10 minutes?

3-178. The number of errors in a textbook follows a Poisson distribution with mean of 0.01 error per page.

(a) What is the probability that there are three or fewer errors in 100 pages?

(b) What is the probability that there are four or more errors in 100 pages?

(c) What is the probability that there are three or fewer errors in 200 pages?

3-179. Continuation of Exercise 3-178. Let Y be the random variable defined as the number of pages between errors.

(a) What is the distribution of Y? What is the mean of Y?

(b) What is the probability that there are fewer than 100 pages between errors?

(c) What is the probability that there are no errors in 200 consecutive pages?

(d) Given that there are 100 consecutive pages without errors, what is the probability that there will not be an error in the next 50 pages?

3-180. Polyelectrolytes are typically used to separate oil and water in industrial applications. The separation process is dependent on controlling the pH. Fifteen pH readings of wastewater following these processes were recorded. Is it reasonable to model these data using a normal distribution?

6.2	6.5	7.6	7.7	7.1	7.1	7.9	8.4
7.0	7.3	6.8	7.6	8.0	7.1	7.0	

3-181. The lifetimes of six major components in a copier are independent exponential random variables with means of 8000, 10,000, 10,000, 20,000, 20,000, and 25,000 hours, respectively.

(a) What is the probability that the lifetimes of all the components exceed 5000 hours?

(b) What is the probability that none of the components have a lifetime that exceeds 5000 hours?

(c) What is the probability that the lifetimes of all the components are less than 3000 hours?

3-182. A random sample of 36 observations has been drawn. Find the probability that the sample mean is in the interval $47 < \bar{X} < 53$, for each of the following population distributions and population parameter values.

(a) Normal with mean 50 and standard deviation 12.

(b) Exponential with mean 50.

(c) Poisson with mean 50.

(d) Compare the probabilities obtained in parts (a)–(c) and explain why the probabilities differ.

3-183. From contractual commitments and extensive past laboratory testing, we know that compressive strength measurements are normally distributed with the true mean compressive strength $\mu = 5500$ psi and standard deviation $\sigma = 100$ psi. A random sample of structural elements is tested for compressive strength at the customer's receiving location.

(a) What is the standard deviation of the sampling distribution of the sample mean for this problem if $n = 9$?

(b) What is the standard deviation of the sampling distribution of the sample mean for this problem if $n = 20$?

(c) Compare your results of parts (a) and (b), and comment on why they are the same or different.

3-184. The weight of adobe bricks for construction is normally distributed with a mean of 3 pounds and a standard deviation of 0.25 pound. Assume that the weights of the bricks are independent and that a random sample of 25 bricks is chosen. What is the probability that the mean weight of the sample is less than 2.95 pounds?

3-185. A disk drive assembly consists of one hard disk and spacers on each side, as shown in Fig. 3-44. The height of the top spacer, W, is normally distributed with mean 120 millimeters and standard deviation 0.5 millimeters, and the height of the disk, X, is normally distributed with mean 20 millimeters and standard deviation 0.1 millimeters, and the height of the bottom spacer, Y, is normally distributed with mean 100 mm and standard deviation 0.4 millimeters.

(a) What are the distribution, the mean, and the variance of the height of the stack?

(b) Assume that the stack must fit into a space with a height of 242 millimeters. What is the probability that the stack height will exceed the space height?

3-186. The time for an automated system in a warehouse to locate a part is normally distributed with a mean of 45 seconds and a standard deviation of 30 seconds. Suppose that independent requests are made for 10 parts.

(a) What is the probability that the average time to locate 10 parts exceeds 60 seconds?

(b) What is the probability that the total time to locate 10 parts exceeds 600 seconds?

3-187. A mechanical assembly used in an automobile engine contains four major components. The weights of the

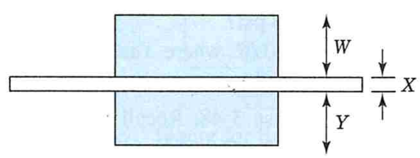


Figure 3-44 Figure for Exercise 3-185.

components are independent and normally distributed with the following means and standard deviations (in ounces).

Component	Mean	Standard Deviation
Left case	4	0.4
Right case	5.5	0.5
Bearing assembly	10	0.2
Bolt assembly	8	0.5

(a) What is the probability that the weight of an assembly exceeds 29.5 ounces?

(b) What is the probability that the mean weight of eight independent assemblies exceeds 29 ounces?

3-188. A bearing assembly contains 10 bearings. The bearing diameters are assumed to be independent and normally distributed with a mean of 1.5 millimeters and a standard deviation of 0.025 millimeter. What is the probability that the maximum diameter bearing in the assembly exceeds 1.6 millimeters?

3-189. A process is said to be of **six-sigma quality** if the process mean is at least six standard deviations from the nearest specification. Assume a normally distributed measurement.

(a) If a process mean is centered between the upper and lower specifications at a distance of six standard deviations from each, what is the probability that a product does not meet specifications? Using the result that 0.000001 equals one part per million, express the answer in parts per million.

(b) Because it is difficult to maintain a process mean centered between the specifications, the probability of a product not meeting specifications is often calculated after assuming the process shifts. If the process mean positioned as in part (a) shifts upward by 1.5 standard deviations, what is the probability that a product does not meet specifications? Express the answer in parts per million.

3-190. Continuation of Exercise 3-63. Recall that it was determined that a normal distribution adequately fit the internal pressure strength data. Use this distribution and suppose that the sample mean of 206.04 and standard deviation of 11.57 are used to estimate the population parameters. Estimate the following probabilities.

(a) What is the probability that the internal pressure strength measurement will be between 210 and 220 psi?

(b) What is the probability that the internal pressure strength measurement will exceed 228 psi?

(c) Find x such that $P(X \geq x) = 0.02$, where X is the internal pressure strength random variable.

3-191. Continuation of Exercise 3-48. Recall that it was determined that a normal distribution adequately fit the dimensional measurements for parts from two different machines. Using this distribution, suppose that $\bar{x}_1 = 100.27$, $s_1 = 2.28$, $\bar{x}_2 = 100.11$, and $s_2 = 7.58$ are used to estimate the population parameters. Estimate the following probabilities. Assume that the engineering specifications indicate that acceptable parts measure between 96 and 104.

(a) What is the probability that machine 1 produces acceptable parts?

(b) What is the probability that machine 2 produces acceptable parts?

(c) Use your answers from parts (a) and (b) to determine which machine is preferable.

(d) Recall that the data reported in Exercise 3-49 were a result of a process engineer making adjustments to machine 2. Use the new sample mean 105.39 and sample standard deviation 2.08 to estimate the population parameters. What is the probability that the newly adjusted machine 2 will produce acceptable parts? Did adjusting machine 2 improve its overall performance?

3-192. Continuation of Exercise 2-1.

(a) Plot the data on normal probability paper. Does concentration appear to have a normal distribution?

(b) Suppose it has been determined that the largest observation, 68.7, was suspected to be an outlier. Consequently, it can be removed from the data set. Does this improve the fit of the normal distribution to the data?

3-193. Continuation of Exercise 2-2.

(a) Plot the data on normal probability paper. Do these data appear to have a normal distribution?

(b) Remove the largest observation from the data set. Does this improve the fit of the normal distribution to the data?

3-194. The weight of a certain type of brick has an expectation of 1.12 kilograms with a variance of 0.0009 kilogram. How many bricks would need to be selected so that their average weight has a standard deviation of no more than 0.005 kilogram?

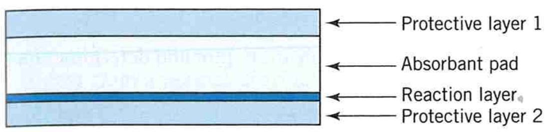
3-195. The thickness of glass sheets produced by a certain process are normally distributed with a mean of $\mu = 3.00$ millimeters and a standard deviation of $\sigma = 0.12$ millimeters. What is the value of c for which there is a 99% probability that a glass sheet has a thickness within the interval $[3.00 - c, 3.00 + c]$?

3-196. The weights of bags filled by a machine are normally distributed with a standard deviation of 0.05 kilograms and mean that can be set by the operator. At what level should the mean be set if it is required that only 1% of the bags weigh less than 10 kilograms?

3-197. The research and development team of a medical device manufacturer is designing a new diagnostic test strip to detect the breath alcohol level. The materials used to make the device are listed here together with their mean and standard deviation of their thickness.

Material	Random Variable	Mean Thickness μ, mm	Standard Deviation of Thickness σ, mm
Protective layer 1	W	10	2
Absorbant pad	X	50	10
Reaction layer	Y	5	1
Protective layer 2	Z	8	1

The materials are stacked as shown in the following figure. Assuming that the thickness of each material is independent and normally distributed, answer the following questions.



(a) Using the random variables W, X, Y, and Z, give the equation representing the thickness of the layered strip.
(b) What is the mean thickness of the strip?
(c) What is the variance of the thickness of the strip?
(d) What is the probability that the thickness of the strip will be greater than 75 millimeters?

3-198. Overheating is a major problem in microprocessor operation. After much testing, it has been determined that the operating temperature is normally distributed with a mean of 150 degrees and a standard deviation of 7 degrees. The processor will malfunction at 165 degrees.

(a) What is the probability of a malfunction?
(b) A newer fan useful for cooling the processor is being considered. With the new fan, the operating temperature has a mean of 144 degrees and a standard deviation of 9 degrees. What is the probability of a malfunction with the new fan?
(c) Suppose that all processors are sold for \$1200. The cost of the original system is \$1000, whereas the cost with the new fan is \$1050. Assume that 1000 units are planned to be produced and sold. Also assume that there is a money-back guarantee for all systems that malfunction. Under these assumptions, which system will generate the most revenue?

3-199. Manufacturers need to determine that each medical linear accelerator works within proper parameters before shipping to hospitals. An individual machine is known to have a probability of failure during initial testing of 0.10. Eight accelerators are tested.

(a) What is the probability that at most two fail?
(b) What is the probability that none fail?

3-200. A keyboard for a personal computer is known to have a mean life of 5 years. The life of the keyboard can be modeled using an exponential distribution.

(a) What is the probability that a keyboard will have a life between 2 and 4 years?
(b) What is the probability that the keyboard will still function after 1 year?
(c) If a warranty is set at the 6 months, what is the probability that a keyboard will need to replaced under warranty?

3-201. A cartridge company develops ink cartridges for a printer company and supplies both the ink and the cartridge. The following is the probability mass function of the number of cartridges over the life of the printer.

x	5	6	7	8	9
$f(x)$	0.04	0.19	0.61	0.13	0.03

(a) What is the expected number of cartridges used?
(b) What is the probability that more than six cartridges are used?
(c) What is the probability that 9 out of 10 randomly selected printers use more than 6 cartridges?

3-202. Consider the following system made up of functional components in parallel and series. The probability that each component functions is shown in Fig. 3-45.

(a) What is the probability that the system operates?
(b) What is the probability that the system fails due to the components in series? Assume parallel components do not fail.
(c) What is the probability that the system fails due to the components in parallel? Assume series components do not fail.
(d) Compute the probability that the system fails using the following formula:

$$[1 - P(C_1) \cdot P(C_4)] \cdot [1 - P(C_2')P(C_4')] + P(C_1) \cdot P(C_4) \cdot P(C_2') \cdot P(C_3') + [1 - P(C_1)P(C_4)] \cdot P(C_2') \cdot P(C_3').$$

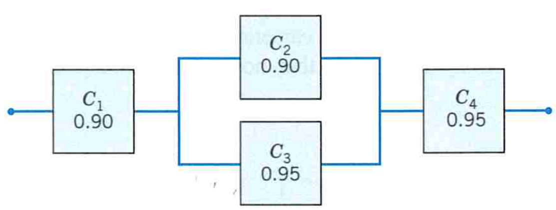


Figure 3-45 Figure for Exercise 3-202.

Section 3-5

3-29. (a) 0 (b) −3.09 (c) −1.18 (d) −1.11 (e) 1.75
3-31. (a) 0.97725 (b) 0.84134 (c) 0.68268 (d) 0.9973 (e) 0.47725 (f) 0.49865
3-33. (a) 0.99865 (b) 0.00023 (c) 0.47725 (d) 0.83513 (e) 0.69123
3-35. (a) 0.9938 (b) 0.1359 (c) 5835.51
3-37. (a) 0.0082 (b) 0.7211 (c) 0.5641
3-39. (a) 12.3069 (b) 12.155
3-41. (a) 0.1587 (b) 90.0 (c) 0.9973
3-43. (a) 0.09012 (b) 0.35888 (c) 13.97
3-45. (a) 0.0668 (b) 0.8664 (c) 0.000214
3-61. $r = 3.24, \lambda = 0.72$

Section 3-7

3-71. (a) 0.433 (b) 0.409 (c) 0.316 (d) $E(X) = 3.319, V(X) = 3.7212$
3-73. (a) 4/7 (b) 3/7 (c) $E(X) = 11/7, V(X) = 26/49$
3-75. (a) 0.170 (b) 0.10 (c) 0.91 (d) $E(X) = 9.98, V(X) = 2.02$

Section 3-8

3-79. (a) 0.0148 (b) 0.8684 (c) 0 (d) 0.1109
3-81. (a) 0.0015 (b) 0.9298 (c) 0 (d) 0.0686
3-83. 0.0043
3-85. (a) $n = 50, p = 0.1$ (b) 0.1117 (c) 0
3-87. (a) 0.9961 (b) 0.9717 (c) $E(X) = 112.5, \sigma = 3.354$
3-89. (a) 0.13422 (b) 0.000001 (c) 0.30199

Section 3-9.1

3-91. (a) 0.7408 (b) 0.9997 (c) 0 (d) 0.0333
3-93. $E(X) = V(X) = 3.912$
3-95. (a) 0.0844 (b) 0.0103 (c) 0.0185 (d) 0.1251
3-97. (a) 4.54×10^{-5} (b) 0.6321
3-99. (a) 0.7261 (b) 0.0731
3-101. 0.2941
3-103. (a) 0.0076 (b) 0.1462
3-105. (a) 0.3679 (b) 0.0498 (c) 0.0183 (d) 14.9787
3-107. (a) 1/3 (b) 1/3 (c) 0.9986
3-109. (a) 0.8111 (b) 0.1010
3-111. (a) 0.1353 (b) 0.2707 (c) 5
3-113. (a) 0.3679 (b) 0.3679 (c) 2
3-115. (a) 0.122 years (b) 33.3 years

Section 3-10

3-117. (a) 0.0002 (b) 0.0002
3-119. (a) 0.1294 (b) 0.4881
3-121. 0.9441
3-123. (a) 0.119 (b) 0.0793 (c) 0.1117 (d) 0.995 (e) 0.983

Section 3-11

3-125. (a) 0.2457 (b) 0.7641 (c) 0.5743 (d) 0.1848
3-127. (a) 0.372 (b) 0.1402 (c) 0.3437 (d) 0.5783
3-129. (a) 0.8404 (b) 0.4033 (c) 0
3-133. (a) 0.8740 (b) 0.1260
3-135. (a) 0.15 (b) 0.08 (c) 0.988

Section 3-12

3-137. (a) 31 (b) 268
3-139. (a) 22 (b) 48 (c) 44 (d) 192
3-141. (a) 0.8770 (b) 0.2886 (c) 0.6826

Section 3-13

3-143. (a) $E(T) = 3, \sigma_T = 0.141$ (b) 0.0169
3-145. (a) $E(X) = 6, \sigma_x = 0.15$ (b) 0.2514
3-147. $E(Y) = 22, V(Y) = 88$
3-149. $E(Y) = 800, V(Y) = 57600$
3-151. $E(P) = 4000, V(P) = 16{,}000{,}000$
3-155. $E(Y) = 24, V(Y) = 644$
3-157. (a) Mean: 100, variance: 81/16 (b) 0.1870 (c) 0.0912 (d) 0.7753
3-159. (a) Mean: 20, variance 1/20 (b) 0 (c) 0 (d) 1
3-161. (a) 0.0016 (b) 6
3-163. 0.4306
3-165. (a) 0.1762 (b) 0.8237 (c) 0.0005
3-167. (a) 0.0791 (b) 0.1038 (c) 0.1867

Supplemental Exercises

3-169. (a) 0.7769 (b) 0.7769 (c) 0.1733 (d) 0 (e) 0.0498
3-171. (a) 0.6 (b) 0.8 (c) 0.7 (d) 3.9 (e) 4.09
3-175. (a) 0.1298 (b) 0.8972 (c) 42.5
3-177. (a) Exponential with mean 12 min. (b) 0.2865 (c) 0.341 (d) 0.436
3-179. (a) Exponential with mean 100 (b) 0.632 (c) 0.1353 (d) 0.6065
3-181. (a) 0.0978 (b) 0.0006 (c) 0.00005
3-183. (a) 33.3 (b) 22.36
3-185. (a) Normal dist.; mean 240, variance 0.42 (b) 0.0010
3-187. (a) 0.0084 (b) 0
3-189. (a) 0.0018 ppm (b) 3.4 ppm
3-191. (a) 0.919 (b) 0.402 (c) Machine 1 (d) 0.252
3-195. 0.309
3-197. (a) $T = W + X + Y + Z$ (b) 73 mm (c) 106 mm^2 (d) 0.57534
3-199. (a) 0.9619 (b) 0.4305
3-201. (a) 69.20 (b) 0.77 (c) 0.2188
3-203. (a) 0.8980, 0.0975, 0.005, 0.102 (b) 0.8529, 0.1450, 0.0025, 0.1471
3-205. (c) 312.825 hours
3-207. (c) 8.65