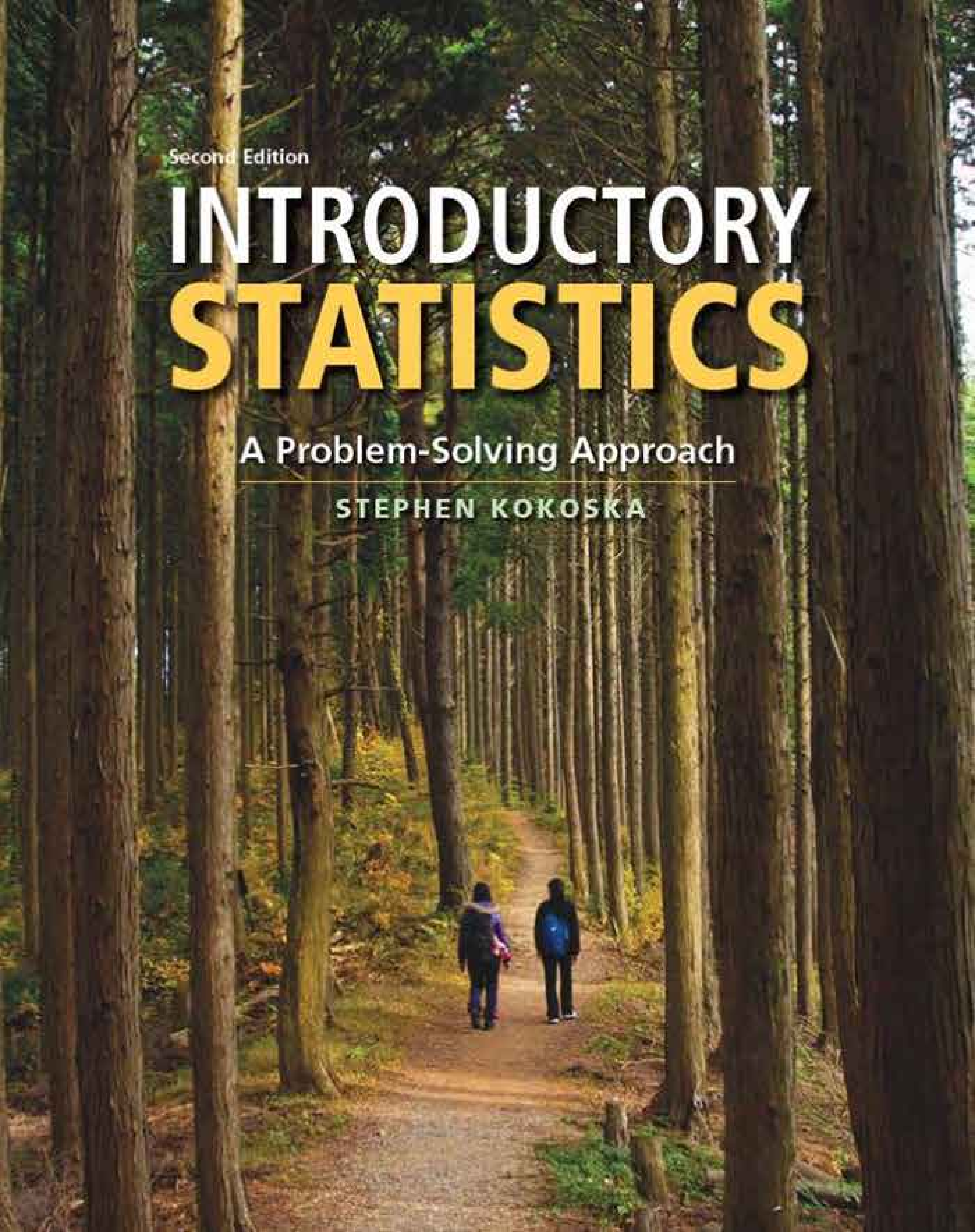
Second Edition

INTRODUCTORY STATISTICS

A Problem-Solving Approach

STEPHEN KOKOSKA



APPLICATIONS

Introductory Statistics: A Problem-Solving Approach, 2e presents a wide variety of applications from diverse disciplines. The following list indicates the Example and Exercise numbers related to different fields. Note that some items appear in more than one category.

EXAMPLES BY APPLICATION

Biology and Environmental Science
1.11, 2.7, 3.2, 3.3, 3.8, 3.9, 3.17, 5.1, 5.2, 6.8, 7.4, 8.5, 9.8, 9.15, 9.19, 10.9, 10.16, 11.2, 11.6, 12.9, 13.1, 14.5

Business and Management
3.5, 4.7, 4.31, 4.36, 4.39, 5.2, 7.3, 7.8, 7.9, 7.11, 9.16, 9.18, 11.3, 14.7, 14.8, 14.9

Demographics and Population Statistics
1.2, 4.1, 4.31, 4.32, 7.1, 9.14, 12.7, 12.8

Economics and Finance
4.14, 10.15, 12.14, 14.1, 14.6, 14.8, 14.10

Education and Child Development
2.3, 3.15, 4.6, 5.11, 6.7, 7.6

Fuel Consumption and Cars
2.13, 3.11, 4.20, 4.38, 8.2, 8.11, 10.10, 12.11, 12.13

Manufacturing and Product Development
1.12, 2.10, 2.11, 4.26, 5.2, 5.20, 6.2, 6.11, 8.7, 8.13, 9.3, 9.4, 9.6, 10.3, 10.5, 12.5

Marketing and Consumer Behavior
1.12, 2.2, 2.3, 2.8, 3.16, 4.4, 4.8, 4.13, 4.15, 4.17, 4.18, 4.19, 4.23, 4.30, 4.34, 4.35, 5.5, 5.14, 5.15, 5.18, 7.1, 7.10, 8.11, 9.14, 10.13, 11.4

Medicine and Clinical Studies
1.3, 1.5, 1.8, 2.9, 3.6, 3.10, 3.14, 3.19, 4.33, 4.37, 5.2, 5.7, 5.16, 6.9, 6.10, 9.1, 9.5, 9.7, 9.9, 9.17, 10.4, 10.8, 12.3, 12.4, 13.3, 14.4

Physical Sciences
1.4, 5.6, 8.10, 10.9, 11.5

Psychology and Human Behavior
1.5, 1.6, 1.8, 1.9, 2.3, 3.6, 4.6, 7.2, 8.8, 9.11, 9.18, 10.1, 10.8, 10.11, 13.2, 14.8

Public Health and Nutrition
2.13, 2.14, 4.37, 5.1, 5.7, 5.10, 6.7, 8.1, 8.3, 8.4, 10.2, 10.6, 10.11, 10.15, 11.1, 11.2, 12.2, 12.7, 12.8, 12.12, 13.3, 14.2, 14.3, 14.4

Public Policy and Political Science
1.10, 3.7, 4.2, 4.3, 4.16, 4.25, 5.4, 5.17, 6.3, 7.1, 8.1, 9.13, 9.15

Sports and Leisure
1.7, 2.1, 3.2, 3.3, 3.12, 3.18, 3.20, 4.10, 4.18, 4.21, 4.22, 4.24, 5.8, 5.12, 5.19, 6.1, 9.10, 10.7, 12.1, 12.10

Technology and the Internet
4.9, 4.19, 8.8, 9.17, 10.1

Travel and Transportation
1.1, 2.3, 2.4, 2.5, 2.6, 2.8, 2.12, 3.3, 3.7, 3.13, 3.17, 3.18, 3.20, 4.2, 4.3, 4.7, 4.27, 4.38, 5.9, 6.1, 6.6, 7.1, 7.7, 8.9, 9.2, 9.12, 10.12, 12.6, 13.4

EXERCISES BY APPLICATION

Biology and Environmental Science
0.7, 0.9, 1.30, 1.36, 1.41, 1.42, 1.43, 2.7, 2.8, 2.9, 2.12, 2.14, 2.22, 2.40, 2.60, 2.63, 2.65, 2.67, 2.86, 2.92, 2.94, 2.109, 3.14, 3.19, 3.21, 3.31, 3.54, 3.55, 3.59, 3.65, 3.84, 3.86, 3.112, 3.134, 4.123, 4.130, 4.146, 4.151, 4.164, 4.177, 5.9, 5.12, 5.15, 5.16, 5.39, 6.47, 6.53, 6.55, 6.58, 6.82, 6.109, 7.16, 7.42, 7.45, 7.46, 7.48, 7.80, 7.91, 7.105, 8.12, 8.13, 8.14, 8.37, 8.44, 8.69, 8.86, 8.149, 8.157, 8.173, 8.177, 9.14, 9.15, 9.73, 9.79, 9.92, 9.121, 9.142, 9.144, 9.157, 9.159, 9.229, 9.236, 9.249, 9.254, 10.47, 10.57, 10.72, 10.74, 10.82, 10.92, 10.137, 10.154, 10.155, 10.159, 10.161, 10.168, 10.169, 11.21, 11.25, 11.26, 11.52, 11.53, 11.55, 11.60, 11.62, 11.77, 11.81, 11.98, 11.100, 12.18, 12.22, 12.28, 12.49, 12.56, 12.57, 12.60, 12.78, 12.81, 12.107, 12.115, 12.146, 12.147, 12.149, 12.153, 12.156, 12.159, 12.165, 13.14, 13.25, 13.70, 14.19, 14.21, 14.38, 14.63, 14.76, 14.114, 14.115, 14.116, 14.118, 14.123, 14.124, 14.128, 14.145, 14.153

Business and Management

1.19, 2.32, 2.61, 2.96, 3.89, 3.105, 3.114, 4.76, 4.78, 4.90, 4.112, 4.131, 4.171, 5.9, 5.38, 5.93, 5.97, 5.98, 5.127, 5.132, 5.139, 5.142, 5.157, 6.95, 6.110, 7.77, 8.11, 8.50, 8.51, 8.75, 8.109, 8.110, 8.113, 8.133, 8.134, 8.145, 8.165, 9.29, 9.72, 9.146, 9.151, 9.222, 9.226, 9.239, 9.251, 9.256, 10.15, 11.28, 11.76, 12.23, 12.58, 12.108, 12.113, 12.142, 13.19, 13.26, 13.29, 13.58, 14.42, 14.59, 14.81

Demographics and Population Statistics

1.28, 1.43, 2.25, 3.80, 4.56, 4.64, 4.129, 4.149, 4.176, 5.43, 5.94, 5.95, 5.128, 7.14, 7.83, 7.90, 9.153, 9.195, 9.197, 11.50, 11.57, 12.83, 13.66

Economics and Finance

1.11, 2.14, 2.103, 3.110, 3.117, 4.20, 4.33, 4.91, 4.120, 4.141, 4.152, 4.157, 4.160, 4.178, 4.188, 5.9, 5.42, 5.87, 5.126, 5.133, 5.140, 6.20, 6.42, 6.117, 7.9, 7.21, 7.107, 8.45, 8.78, 8.107, 8.116, 8.160, 9.30, 9.50, 9.77, 9.148, 9.232, 9.257, 10.28, 10.60, 10.72, 10.102, 10.165, 10.167, 11.103, 12.61, 12.141, 12.150, 12.155, 12.161, 12.164, 13.13, 13.63, 14.35, 14.37, 14.100, 14.125

Education and Child Development

2.6, 2.21, 2.26, 3.17, 3.22, 3.47, 3.87, 3.108, 3.126, 4.94, 4.141, 5.14, 5.65, 6.76, 7.17, 7.76, 8.115, 9.12, 9.22, 9.46, 9.181, 9.192, 10.72, 13.46, 13.62, 14.102

Fuel Consumption and Cars

0.11, 1.5, 1.27, 1.31, 1.37, 2.5, 2.23, 2.87, 2.95, 2.97, 2.104, 2.106, 3.16, 3.29, 3.46, 4.22, 4.83, 4.85, 4.111, 4.142, 4.169, 4.190, 5.10, 5.33, 5.88, 6.94, 6.111, 6.118, 7.18, 7.57, 8.71, 8.139, 8.144, 9.89, 9.96, 9.114, 9.155, 10.45, 10.74, 10.91, 10.150, 11.23, 11.30, 12.54, 12.77, 12.140, 14.14, 14.62, 14.122, 14.140

Manufacturing and Product Development

1.6, 1.14, 1.16, 1.17, 1.29, 1.32, 1.33, 1.38, 1.39, 1.42, 1.52, 1.53, 2.12, 2.13, 2.62, 2.90, 2.102, 3.18, 3.26, 3.30, 3.83, 3.91, 3.93, 3.119, 3.121, 3.123, 3.128, 3.132, 3.133, 4.24, 4.52, 4.65, 4.84, 4.96, 4.112, 4.167, 4.172, 4.183, 5.12, 5,32, 5.37, 5.56, 5.62, 5.101, 5.103, 5.125, 5.141, 5.157, 6.12, 6.14, 6.45, 6.56, 6.59, 6.61, 6.83, 6.112, 6.116, 6.123, 6.124, 7.10, 7.11, 7.13, 7.41, 7.43, 7.54, 7.55, 7.59, 7.81, 7.82, 7.84, 7.86, 7.98, 7.100, 7.104, 8.15, 8.67, 9.68, 8.138, 8.146, 8.161, 8.175, 9.49, 9.82, 9.84, 9.90, 9.91, 9.97, 9.116, 9.118, 9.119, 9.120, 9.217, 9.219, 9.221, 9.225, 9.227, 9.228, 9.230, 9.231, 9.233, 9.234, 9.237, 9.245, 9.255, 10.14, 10.16, 10.19, 10.21, 10.23, 10.46, 10.48, 10.50, 10.52, 10.53, 10.55, 10.56, 10.64, 10.73, 10.87, 10.115, 10.120, 10.144, 10.145, 10.147, 10.158, 10.164, 11.16, 11.24, 11.29, 11.51, 11.63, 11.90, 11.91, 11.93, 12.21, 12.31, 12.104, 12.106, 12.162, 12.167, 12.170, 14.15, 14.16, 14.57, 14.96, 14.101, 14.132, 14.135, 14.138, 14.147, 14.148

Marketing and Consumer Behavior

1.5, 1.6, 1.7, 1.12, 1.18, 1.40, 1.41, 1.43, 1.45, 2.6, 2.7, 2.8, 2.11, 2.29, 2.31, 2.33, 2.38, 2.88, 3.51, 3.56, 3.90, 3.95, 4.35, 4.37, 4.55, 4.58, 4.60, 4.63, 4.67, 4.79, 4.81, 4.92, 4.112, 4.126, 4.127, 4.141, 4.142, 4.173, 4.179, 4.185, 4.194, 5.13, 5.36, 5.64, 5.89, 5.100, 5.102, 5.130, 5.148, 5.149, 5.154, 6.18, 6.19, 6.22, 6.43, 6.46, 6.54, 6.81, 6.100, 6.108, 6.126, 7.9, 7.11, 7.72, 7.74, 7.88, 7.89, 7.92, 8.34, 8.77, 8.102, 8.105, 8.108, 8.111, 8.153, 8.158, 9.13, 9.16, 9.53, 9.74, 9.83, 9.93, 9.94, 9.147, 9.152, 9.156, 9.164, 9.186, 9.253, 10.18, 10.27, 10.61, 10.102, 10.109, 10.119, 11.19, 11.99, 12.163, 13.12, 13.15, 13.16, 13.17, 13.22, 13.23, 13.43, 13.44, 13.56, 13.60, 13.65, 13.69, 13.71, 14.97, 14.137, 14.149

Medicine and Clinical Studies

0.4, 0.10, 0.13, 1.5, 1.6, 1.7, 1.15, 1.42, 1.46, 2.5, 2.105, 3.28, 3.124, 4.27, 4.66, 4.86, 4.111, 4.134, 4.155, 4.162, 4.165, 4.180, 4.184, 5.9, 5.12, 5.18, 5.153, 5.155, 5.158, 6.21, 6.57, 6.99, 7.9, 7.10, 7.96, 8.17, 8.81, 8.117, 8.148, 8.152, 8.156, 8.162, 8.169, 8.174, 9.24, 9.47, 9.52, 9.56, 9.113, 9.149, 9.150, 9.183, 9.194, 9.238, 9.244, 9.246, 10.20, 10.24, 10.49, 10.58, 10.73, 10.74, 10.90, 10.113, 10.122, 10.138, 11.22, 11.49, 11.85, 11.87, 12.26, 12.27, 12.29, 12.33, 12.87, 12.105, 12.110, 12.111, 12.154, 12.160, 12.168, 13.50, 14.13, 14.22, 14.23, 14.32, 14.33, 14.55, 14.103, 14.146

Physical Sciences

1.5, 1.49, 2.57, 2.58, 2.99, 3.45, 3.50, 3.52, 3.85, 3.127, 3.129, 3.130, 3.131, 4.19, 4.23, 4.153, 4.174, 5.121, 5.123, 5.131, 6.16, 6.60, 6.79, 6.101, 6.119, 7.10, 7.11, 7.50, 7.87, 7.93, 7.102, 8.31, 8.35, 8.42, 8.70, 8.136, 8.137, 8.143, 8.151, 8.167, 9.17, 9.45, 9.55, 9.75, 9.95, 9.160, 9.161, 9.188, 9.193, 9.215, 9.216, 9.235, 9.248, 9.250, 10.26, 10.59, 10.62, 10.63, 10.79, 10.83, 10.148, 10.151, 10.156, 10.170, 11.27, 11.31, 11.89, 11.96, 12.19, 12.30, 12.50, 12.51, 12.55, 12.62, 12.63, 12.76, 12.86, 12.88, 12.103, 12.109, 12.114, 12.139, 12.143, 12.144, 12.145, 12.148, 12.173, 13.68, 14.41, 14.75, 14.82, 14.120, 14.127, 14.136

Psychology and Human Behavior

0.12, 1.9, 1.12, 1.13, 2.19, 2.20, 2.30, 2.43, 2.55, 2.98, 4.28, 4.62, 4.87, 4.95, 4.97, 4.103, 4.128, 4.132, 4.156, 4.161, 4.181, 4.189, 5.17, 5.61, 5.66, 5.104, 5.119, 5.135, 5.147, 6.17, 6.23, 6.50, 6.96, 6.103, 7.10, 7.22, 7.44, 7.79, 8.47, 8.79, 8.114, 8.147, 8.163, 8.166, 9.51, 9.165, 9.180, 9.185, 10.85, 10.88, 10.102, 10.112, 10.117, 10.121, 10.162, 11.84, 12.25, 12.75, 12.82, 13.11, 13.24, 13.47, 13.53, 13.55, 13.59, 13.64, 13.67, 14.77, 14.99, 14.121, 14.150

Public Health and Nutrition

1.5, 1.6, 1.12, 1.43, 1.44, 1.54, 2.27, 2.56, 2.59, 2.89, 2.108, 3.24, 3.53, 3.61, 3.109, 3.115, 3.118, 4.29, 4.31, 4.54, 4.57, 4.133, 4.168, 4.186, 5.12, 5.59, 5.60, 5.91, 5.96, 5.134, 5.138, 5.156, 5.158, 6.48, 6.49, 6.75, 6.98, 6.102, 6.106, 6.107, 6.115, 6.122, 7.9, 7.15, 7.39, 7.47, 7.51, 7.70, 7.75, 7.101, 8.18, 8.32, 8.49, 8.83, 8.87, 8.100, 8.150, 8.168, 8.170, 8.172, 8.176, 9.31, 9.78, 9.85, 9.87, 9.111, 9.162, 9.163, 9.179, 9.218, 9.224, 9.242, 9.252, 10.25, 10.74, 10.81, 10.84, 10.86, 10.89, 10.106, 10.110, 10.114, 10.149, 10.160, 10.171, 11.15, 11.20, 11.56, 11.58, 11.61, 11.75, 11.86, 11.94, 11.101, 11.102, 12.32, 12.52, 12.59, 12.79, 12.151, 12.157, 12.172, 13.18, 13.20, 13.51, 13.57, 14.39, 14.61, 14.78, 14.117, 14.129, 14.131, 14.141, 14.142, 14.144

Public Policy and Political Science

1.5, 1.10, 1.12, 1.41, 1.47, 2.5, 2.24, 2.34, 2.42, 3.49, 3.107, 3.111, 3.113, 3.116, 4.82, 4.98, 4.105, 4.125, 4.135, 4.150, 4.154, 5.10, 5.34, 5.35, 5.58, 5.92, 5.150, 6.44, 6.78, 6.93, 6.97, 7.11, 7.40, 7.107, 8.41, 8.80, 8.101, 8.104, 8.106, 8.118, 9.21, 9.25, 9.26, 9.27, 9.28, 9.44, 9.48, 9.81, 9.86, 9.122, 9.145, 9.166, 9.182, 9.184, 9.187, 9.189, 9.190, 9.196, 9.240, 9.241, 9.247, 10.17, 10.107, 10.153, 10,163, 10.166, 11.33, 11.79, 12.85, 13.28, 13.45, 13.52, 13.54, 13.61, 14.34, 14.79, 14.95, 14.98

Sports and Leisure

0.5, 0.6, 0.8, 1.6, 1.34, 2.5, 2.10, 2.11, 2.12, 2.13, 2.28, 2.36, 2.41, 2.64, 2.91, 2.107, 3.20, 3.23, 3.27, 3.44, 3.82, 3.92, 3.120, 3.122, 3.125, 3.135, 4.7, 4.9, 4.25, 4.26, 4.59, 4.77, 4.88, 4.89, 4.99, 4.102, 4.111, 4.112, 4.119, 4.121, 4.124, 4.158, 4.159, 4.170, 4.175, 4.193, 5.9, 5.19, 5.40, 5.41, 5.57, 5.63, 5.90, 5.99, 5.105, 5.124, 5.129, 5.144, 5.146, 6.13, 6.25, 6.51, 6.52, 6.62, 6.63, 6.77, 6.80, 6.114, 7.12, 7.20, 7.24, 7.49, 7.52, 7.53, 7.56, 7.73, 7.78, 7.103, 7.106, 8.33, 8.46, 8.48, 8.52, 8.72, 8.76, 8.82, 8.84, 8.85, 8.140, 8.141, 8.154, 8.159, 8.171, 9.19, 9.54, 9.76, 9.112, 9.115, 9.154, 9.158, 9.220, 9.223, 10.54, 10.74, 10.80, 10.116, 10.140, 10.141, 10.142, 10.146, 10.157, 11.18, 11.32, 11.54, 11.59, 11.78, 11.82, 11.88, 11.97, 12.20, 12.24, 12.48, 12.53, 12.64, 12.112, 12.116, 12.169, 13.21, 13.42, 13.48, 13.49, 14.17, 14.36, 14.58, 14.80, 14.119, 14.126, 14.134, 14.151

Technology and the Internet

1.50, 2.100, 2.101, 3.15, 3.32, 3.62, 4.61, 4.112, 4.142, 5.120, 5.145, 6.105, 6.113, 7.9, 7.71, 7.94, 8.38, 8.43, 8.73, 8.119, 8.135, 8.164, 9.18, 9.80, 9.123, 9.191, 10.78, 10.108, 10.118, 11.92, 12.84, 12.158, 14.56, 14.60, 14.133

Travel and Transportation

1.12, 1.35, 1.41, 1.48, 1.51, 2.6, 2.8, 2.14, 2.35, 2.37, 2.39, 2.66, 2.93, 3.13, 3.25, 3.48, 3.57, 3.58, 3.81, 3.88, 3.94, 3.106, 3.136, 4.21, 4.30, 4.32, 4.36, 4.53, 4.93, 4.104, 4.111, 4.121, 4.122, 4.163, 4.166, 4.182, 4.187, 4.191, 4.192, 4.193, 4.194, 5.9, 5.10, 5.12, 5.122, 5.143, 6.15, 6.120, 6.121, 7.10, 7.19, 7.99, 8.16, 8.36, 8.40, 8.74, 8.103, 8.112, 8.142, 9.20, 9.23, 9.43, 9.117, 9.143, 9.243, 10.22, 10.51, 10.72, 10.73, 10.93, 10.111, 10.139, 10.143, 10.152, 11.17, 11.80, 11.83, 11.95, 12.80, 12.152, 12.166, 12.171, 13.27, 13.72, 14.18, 14.20, 14.40, 14.74, 14.113, 14.130, 14.139, 14.143, 14.152

INTRODUCTORY STATISTICS

Omar Harran/Moment/Getty Images

SECOND EDITION

INTRODUCTORY STATISTICS

A Problem-Solving Approach

Stephen Kokoska

Bloomsburg University

W. H. Freeman & Company

A Macmillan Education Imprint

Senior Publisher: Terri Ward
Senior Acquisitions Editor: Karen Carson
Marketing Manager: Cara LeClair
Development Editor: Leslie Lahr
Associate Editor: Marie Dripchak
Senior Media Editor: Laura Judge
Media Editor: Catriona Kaplan
Associate Media Editor: Liam Ferguson
Editorial Assistant: Victoria Garvey
Marketing Assistant: Bailey James
Photo Editor: Robin Fadool
Cover Designer: Vicki Tomaselli
Text Designer: Jerry Wilke
Managing Editor: Lisa Kinne
Senior Project Manager: Dennis Free, Aptara®, Inc.
Illustrations and Composition: Aptara®, Inc.
Production Coordinator: Julia DeRosa
Printing and Binding: QuadGraphics
Cover credit: Omar Harran/Moment/Getty Images

Library of Preassigned Control Number: 2014950583

Student Edition Hardcover (packaged with EESEE/CrunchIt! access card):
ISBN-13: 978-1-4641-1169-3
ISBN-10: 1-4641-1169-3

Student Edition Loose-leaf (packaged with EESEE/CrunchIt! access card):
ISBN-13: 978-1-4641-5752-3
ISBN-10: 1-4641-5752-9

Instructor Complimentary Copy:
ISBN-13: 978-1-4641-7986-0
ISBN-10: 1-4641-7986-7

Printed in the United States of America

First printing

W. H. Freeman and Company
41 Madison Avenue
New York, NY 10010
Houndmills, Basingstoke RG21 6XS, England
www.whfreeman.com

BRIEF CONTENTS

Optional Sections

(available online at **www.whfreeman.com/introstats2e** and on **LaunchPad**):

CONTENTS

PREFACE

Students frequently ask me why they need to take an introductory statistics course. My answer is simple. In almost every occupation and in ordinary daily life, you will have to make data-driven decisions, inferences, as well as assess risk. In addition, you must be able to translate complex problems into manageable pieces, recognize patterns, and most important, solve problems. This text helps students develop the fundamental lifelong tool of solving problems and interpreting solutions in real-world terms.

One of my goals was to make this problem-solving approach accessible and easy to apply in many situations. I certainly want students to appreciate the beauty of statistics and the connections to so many other disciplines. However, it is even more important for students to be able to apply problem-solving skills to a wide range of academic and career pursuits, including business, science and technology, and education.

Introductory Statistics: A Problem-Solving Approach, Second Edition, presents long-term, universal skills for students taking a one- or two-semester introductory-level statistics course. Examples include guided, explanatory Solution Trails that emphasize problem-solving techniques. Example solutions are presented in a numbered, step-by-step format. The generous collection and variety of exercises provide ample opportunity for practice and review. Concepts, examples, and exercises are presented from a practical, realistic perspective. Real and realistic data sets are current and relevant. The text uses mathematically correct notation and symbols and precise definitions to illustrate statistical procedures and proper communication.

This text is designed to help students fully understand the steps in basic statistical arguments, emphasizing the importance of assumptions in order to follow valid arguments or identify inaccurate conclusions. Most important, students will understand the process of statistical inference. A four-step process (Claim, Experiment, Likelihood, Conclusion) is used throughout the text to present the smaller pieces of introductory statistics on which the larger, essential statistical inference puzzle is built.

NEW TO THIS EDITION

In this thoroughly updated new edition, Steve Kokoska again combines a classic approach to teaching statistics with contemporary examples, pedagogical features, and use of technology. He blends solid mathematics with lucid, often humorous, writing and a distinctive stepped "Solution Trail" problem-solving approach, which helps students understand the processes behind basic statistical arguments, statistical inference, and data-based decision making.

LaunchPad

Introductory Statistics is accompanied by its own dedicated version of W. H. Freeman's breakthrough online course space, which offers the following:

- Pre-built Units for each chapter, curated by experienced educators, with media for each chapter organized and ready to assign or customize to suit the course.
- All online resources for the text in one location, including an interactive e-Book, LearningCurve adaptive quizzing, Try It Now exercises, StatTutors, video technology manuals, statistical applets, CrunchIt! and JMP statistical software, EESEE case studies, and statistical videos.
- Intuitive and useful analytics, with a Gradebook that allows instructors to see how the class is progressing, for individual students and as a whole.
- A streamlined and intuitive interface that lets instructors build an entire course in minutes.

New Solution Trail Exercises

Kokoska's unique "Solution Trail" framework appears in the text margins alongside selected examples. This feature, highly praised by reviewers, serves as a unique guide for approaching and solving the problems before moving to the solution steps within the example. To allow students to put this guidance to use, exercise sets now feature questions that ask students to create their own solution trails.

New Concept Check Exercises

Strengthening the book's conceptual coverage, these exercises open each exercise set with true/false, fill-in-the-blank, and short-answer questions that help students solidify their understanding of the reading and the essential statistical ideas.

New Chapter 0

This introductory chapter eases students into the course and Kokoska's approach. It includes about a dozen exercises that instructors can assign for the first day of class, helping students settle into the course more easily.

Revised Chapter Openers that include "Looking Forward/ Looking Back"

"Looking Back" recaps key concepts learned in prior chapters. "Looking Forward" lists the key concepts to be covered within the chapter.

New "Last Step" Exercises Based on Opening Scenarios

The chapter-opening question is presented again as an exercise at the end of the chapter, to close the concept and application loop, as a last step. In addition, this gives instructors the option of making the scenarios assignable and assessable.

Try It Now References

Most examples include a reference to a specific related exercise in the end-of-chapter set. With this, students can test their understanding of the example's concepts and techniques immediately.

Approximately 40% New and Updated Exercises and Examples

Approximately 100 new examples and almost 800 new exercises are included in this new edition.

More Statistical Technology Integration

In addition to presenting Excel, Minitab, and TI output and instruction, the new edition incorporates sample output screens and guidance for both CrunchIt!, W. H. Freeman's web-based statistical software, and JMP. (CrunchIt! and JMP packages are available free of charge in LaunchPad.)

FEATURES

Focus on Statistical Inference The main theme of this text is statistical inference and decision making through interpretation of numerical results. The process of statistical inference is introduced in a variety of contexts, all using a similar, carefully delineated, four-step approach: Claim, Experiment, Likelihood, and Conclusion.

Can the Florida Everglades be saved?

Burmese pythons have invaded the Florida Everglades and now threaten the wildlife indigenous to the area. It is likely that people were keeping pythons as pets and somehow a few animals slithered into Everglades National Park. The first python was found in the Everglades in 1979, and these snakes became an officially established species in 2000.[1] The Everglades has an ideal climate for the pythons, and the large areas of grass allow the snakes plenty of places to hide.

In January 2013, the Florida Fish and Wildlife Conservation Commission started the Python Challenge. The purpose of the contest was to thin the python population, which could be tens of thousands, and help save the natural wildlife in the Everglades. There were 800 participants, with prizes for the most pythons captured and for the longest. At the end of the competition, 68 Burmese pythons had been harvested.

Suppose a random sample of pythons captured during the Challenge was obtained. The length (in feet) of each python is given in the following table.

9.3	3.5	5.2	8.3	4.6	11.1	10.5	3.7	2.8	5.9
7.4	14.2	13.6	8.3	7.5	5.2	6.4	12.0	10.7	4.0
11.1	3.7	7.0	12.2	5.2	8.1	4.2	6.1	6.3	13.2
3.9	6.7	3.3	8.3	10.9	9.5	9.4	4.3	4.6	5.8
4.1	5.2	4.7	5.8	6.4	3.8	7.1	4.6	7.5	6.0

The tabular and graphical techniques presented in this chapter will be used to describe the shape, center, and spread of this distribution of python lengths and to identify any outliers.

Chapter Opener Each chapter begins with a unique, real-world question, providing an interesting introduction to new concepts and an application to begin discussion. The chapter question is presented again as an exercise at the end of the chapter, to close the concept and application loop, as a last step.

◂ Looking Back

- Recall that $\bar{x}$, $\hat{p}$, and s^2 are the point estimates for the parameters μ, p, and σ^2.
- Remember how to construct and interpret confidence intervals.
- Think about the concept of a sampling distribution for a statistic and the process of standardization.

▸ Looking Forward

- Use the available information in a sample to make a specific decision about a population parameter.
- Understand the formal decision process and learn the four-part hypothesis test procedure.
- Conduct formal hypothesis tests concerning the population parameters μ, p, and σ^2.

Looking Back and Looking Forward At the beginning of almost every chapter, "Looking Back" includes reminders of specific concepts from earlier chapters that will be used to develop new skills. "Looking Forward" offers the learning objectives for the chapter.

Solution Trail 9.8

KEYWORDS
- Is there any evidence?
- Greater than the long-term mean
- Standard deviation 1850
- Random sample

TRANSLATION
- Conduct a one-sided, right-tailed test about a population mean μ
- $\mu_0 = 5960$
- $\sigma = 1850$

CONCEPTS
- Hypothesis test concerning a population mean when σ is known

VISION

Use the template for a one-sided, right-tailed test about μ. The underlying population distribution is unknown, but n is large and σ is known. Determine the appropriate alternative hypothesis and the corresponding rejection region, find the value of the test statistic, and draw a conclusion.

Solution Trail The Solution Trail is a structured technique and visual aid for solving problems that appears in the text margins alongside selected examples. Solution Trails serve as guides for approaching and solving the problems before moving to the solution steps within the example. The four steps of the Solution Trail are

1. Find the *keywords*.
2. Correctly *translate* these words into statistics.
3. Determine the applicable *concepts*.
4. Develop a *vision* for the solution.

The *keywords* lead to a *translation* into statistics. Then, the statistics question is solved with the use of specific *concepts*. Finally, the keywords, translation, and concepts are all used to develop a *vision* for the solution. This method encourages students to think conceptually before making calculations. Selected exercises ask students to write a formal Solution Trail.

Step-by-Step Solutions The solutions to selected examples are presented in logical, systematic steps. Each line in a calculation is explained so that the reader can clearly follow each step in a solution.

SOLUTION

STEP 1 Find the sample mean:

$$\bar{x} = \frac{1}{5}(6.2 + 4.5 + 6.6 + 7.0 + 8.2) = \frac{1}{5}(32.5) = 6.5$$

STEP 2 Use Equation 3.4 to find the sample variance.

$$s^2 = \frac{1}{4}[(6.2 - 6.5)^2 + (4.5 - 6.5)^2 + (6.6 - 6.5)^2 + (7.0 - 6.5)^2 + (8.2 - 6.5)^2]$$ Use data and $\bar{x}$.

$$= \frac{1}{4}[(-0.3)^2 + (-2.0)^2 + (0.1)^2 + (0.5)^2 + (1.7)^2]$$ Compute differences.

$$= \frac{1}{4}[0.09 + 4.0 + 0.01 + 0.25 + 2.89]$$ Square each difference.

$$= \frac{1}{4}(7.24) = 1.81$$ Add, divide by 4.

STEP 3 Take the positive square root of the variance to find the standard deviation.

$$s = \sqrt{1.81} \approx 1.3454$$

A technology solution is shown in Figure 3.17.

The points do not lie along a straight line. Each tail is flat, which makes the graph look S-shaped. This suggests that the underlying population is not normal. Figure 6.64 shows a technology solution.

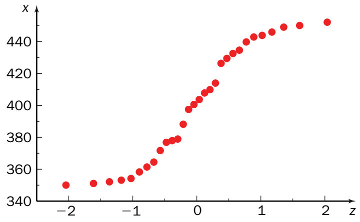


Figure 6.63 Normal probability plot for the chemotherapy dose data.

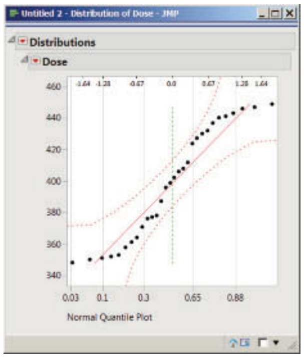
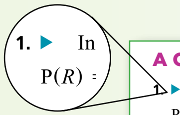


Figure 6.64 JMP normal probability plot.

Technology Solutions Wherever possible, a technology solution using CrunchIt!, JMP, the TI-84, Minitab, or Excel is presented at the end of each text example. This allows students to focus on concepts and interpretation.

A Closer Look The details provided in these sections offer straightforward explanations of various definitions and concepts. The itemized specifics, including hints, tips, and reminders, make it easier for the reader to comprehend and learn important statistical ideas.



Theory Symbols More advanced material, which may be found in "A Closer Look" and regular exposition as appropriate, is offset with a blue triangle. This material can be skipped by the typical reader, but provides more complete explanations to various topics.

A CLOSER LOOK

1. ▶ In Example 4.32,

$$P(R) = P(R \cap M) + P(R \cap F)$$
$$= P(R \cap M) + P(R \cap M')$$

In general, for any two events A and B,

$$P(A) = P(A \cap B) + P(A \cap B')$$

This *decomposition* technique is often needed in order to find $P(A)$. The Venn diagram in Figure 4.19 illustrates this equation.

The events B and B' make up the entire sample space: $S = B \cup B'$.

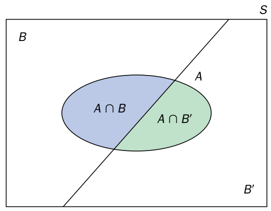


Figure 4.19 Venn diagram showing decomposition of the event A.

2. Suppose B_1, B_2, and B_3 are mutually exclusive and *exhaustive*: $B_1 \cup B_2 \cup B_3 = S$. For any other event A, $P(A) = P(A \cap B_1) + P(A \cap B_2) + P(A \cap B_3)$ ◀

How To Boxes This feature provides clear steps for constructing basic graphs or performing essential calculations. How To boxes are color-coded and easy to locate within each chapter.

How to Construct a Standard Box Plot

Given a set of n observations $x_1, x_2, \ldots, x_n$:

1. Find the five-number summary $x_{\min}$, Q_1, $\tilde{x}$, Q_3, $x_{\max}$.
2. Draw a (horizontal) measurement axis. Carefully sketch a box with edges at the quartiles: left edge at Q_1, right edge at Q_3. (The height of the box is irrelevant.)
3. Draw a vertical line in the box at the median.
4. Draw a horizontal line (whisker) from the left edge of the box to the minimum value (from Q_1 to $x_{\min}$). Draw a horizontal line (whisker) from the right edge of the box to the maximum value (from Q_3 to $x_{\max}$).

Definition/Formula Boxes Definitions and formulas are clearly marked and outlined with clean, crisp color-coded lines.

Definition

The **sample (arithmetic) mean**, denoted $\bar{x}$, of the n observations $x_1, x_2, \ldots, x_n$ is the sum of the observations divided by n. Written mathematically.

$$\bar{x} = \frac{1}{n}\sum x_i = \frac{x_1 + x_2 + \cdots + x_n}{n} \qquad (3.1)$$

Technology Corner This feature, at the end of most sections, presents step-by-step instructions for using CrunchIt!, the TI-84, Minitab, and Excel to solve the examples presented in that section. Keystrokes, menu items, specific functions, and screen illustrations are presented.

Technology Corner

Procedure: Compute the sample mean, sample median, a trimmed mean, and the mode.
Reconsider: Example 3.2, solution, and interpretations.

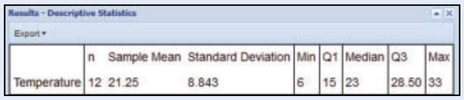


Figure 3.8 CrunchIt! descriptive statistics.

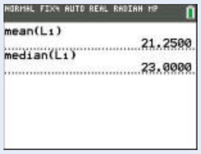


Figure 3.9 The sample mean and the sample median using built-in calculator functions.

Figure 3.10 The sample mean is part of the output from the `1-Var Stats` function.

Figure 3.11 The second output screen from `1-Var Stats` shows the sample median (`Med`).

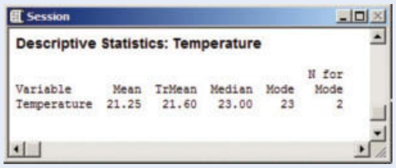


Figure 3.12 Minitab descriptive statistics.

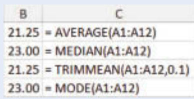


Figure 3.13 Excel descriptive statistics.

Helpful Icons

CUBETIME

Data Set icons indicate when a data set is available online, and also the name of the data set.

STATISTICAL APPLET
MEAN AND MEDIAN

Statistical Applet icons indicate statistical applets that are available in LaunchPad.

STEPPED TUTORIAL
BOX PLOTS

Stepped Tutorial icons indicate detailed tutorials for specific calculations.

VIDEO TECH MANUALS
SAMPLING FROM A DATA SET

Video Tech Manual icons indicate video instructions for solving certain kinds of problems using statistical software.

Solution Trail icons within the exercise sets indicate the opportunity for students to create their own Solution Trails.

Grouped Exercises Kokoska offers a wide variety of interesting, engaging exercises on relevant topics, based on current data, at the end of each section and chapter. These problems provide plenty of opportunity for practice, review, and application of concepts. Answers to odd-numbered section and chapter exercises are given at the back of the book. Exercises are grouped according to:

Concept Check

2.73 True/False A histogram can be used to describe the shape, center, and variability of a distribution.

2.74 Short Answer
- **a.** When is a density histogram appropriate?
- **b.** In a density histogram, what is the sum of areas of all rectangles?

2.75 Fill in the Blank
- **a.** The most common unimodal distribution is a ____________.
- **b.** A unimodal distribution is ____________ if there is a vertical line of symmetry.
- **c.** If a unimodal distribution is not symmetric, then it is ____________.

Concept Check

True/False, Fill-in-the-Blank, and Short-Answer exercises designed to reinforce the basic concepts presented in the section.

Practice

2.77 Consider the data given in the following table. EX2.77

87	81	86	90	88	85	79	91	87	82
91	86	86	87	88	85	92	85	87	86
91	81	89	89	83	90	83	80	90	80
89	85	86	90	90	89	78	91	83	92

Construct a frequency distribution to summarize these data using the class intervals 78–80, 80–82, 82–84, ...

2.78 Consider the data given on the text website. Construct a frequency distribution to summarize these data. EX2.78

Practice

Basic, introductory problems to familiarize students with the concepts and solution methods.

Applications

2.86 Biology and Environmental Science A weather station located along the Maine coast in Kennebunkport collects data on temperature, wind speed, wind chill, and rain. The maximum wind speed (in miles per hour) for 50 randomly selected times in February 2013 are given on the text website.[27] MAXWIND

a. Construct a frequency distribution to summarize these data, and draw the corresponding histogram.

b. Describe the shape of the distribution. Are there any outliers?

Applications

Realistic, appealing exercises to build confidence and promote routine understanding. Many exercises are based on interesting and carefully researched data.

Extended Applications

2.92 Biology and Environmental Science Fruits such as cherries and grapes are harvested and placed in a shallow box or crate called a lug. The size of a lug varies, but one typically holds between 16 and 28 pounds. A random sample of the weight (in pounds) of full lugs holding peaches was obtained, and the data are summarized in the following table.

Class	Frequency
20.0–20.5	6
20.5–21.0	12
21.0–21.5	17
21.5–22.0	21
22.0–22.5	28
22.5–23.0	25
23.0–23.5	19
23.5–24.0	15
24.0–24.5	11
24.5–25.0	10

a. Complete the frequency distribution.

b. Construct a histogram corresponding to this frequency distribution.

c. Estimate the weight *w* such that 90% of all full peach lugs weigh more than *w*.

Extended Applications

Applied problems that require extra care and thought.

CHALLENGE

2.107 Sports and Leisure An *ogive*, or *cumulative relative frequency polygon*, is another type of visual representation of a frequency distribution. To construct an ogive:

- Plot each point (upper endpoint of class interval, cumulative relative frequency).
- Connect the points with line segments.

Figures 2.52 and 2.53 show a frequency distribution and the corresponding ogive. The observations are ages. The values to be used in the plot are shown in bold in the table.

Class	Frequency	Relative frequency	Cumulative relative frequency
12–**16**	8	0.08	**0.08**
16–**20**	10	0.10	**0.18**
20–**24**	20	0.20	**0.38**
24–**28**	30	0.30	**0.68**
28–**32**	15	0.15	**0.83**
32–**36**	10	0.10	**0.93**
32–**40**	7	0.07	**1.00**
Total	100	1.00	

Figure 2.52 Frequency distribution.

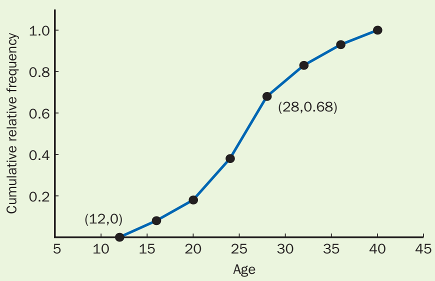


Figure 2.53 Resulting ogive.

A random sample of game scores from Abby Sciuto's evening bowling league with Sister Rosita was obtained, and the data are given on the text website. BOWLING

a. Construct a frequency distribution for these data.

b. Draw the resulting ogive for these data.

Challenge

Additional exercises and technology projects that allow students to discover more advanced concepts and connections.

Last Step

Each set of chapter exercises concludes with the "Last Step." This exercise is connected to the chapter-opening question and the solution involves the skills and concepts presented in the chapter.

LAST STEP

2.109 Can the Florida Everglades be saved? In January 2013, the Florida Fish and Wildlife Conservation Commission started the Python Challenge. The purpose of the contest was to thin the python population, which could be tens of thousands, and help save the natural wildlife in the Everglades. At the end of the competition, 68 Burmese pythons had been harvested. Suppose a random sample of pythons captured during the Challenge was obtained and the length (in feet) of each is given in the following table: PYTHON

9.3	3.5	5.2	8.3	4.6	11.1	10.5	3.7	2.8	5.9
7.4	14.2	13.6	8.3	7.5	5.2	6.4	12.0	10.7	4.0
11.1	3.7	7.0	12.2	5.2	8.1	4.2	6.1	6.3	13.2
3.9	6.7	3.3	8.3	10.9	9.5	9.4	4.3	4.6	5.8
4.1	5.2	4.7	5.8	6.4	3.8	7.1	4.6	7.5	6.0

a. Construct a frequency distribution, stem-and-leaf plot, and histogram for these data.

b. Use these tabular and graphical techniques to describe the shape, center, and spread of this distribution, and to identify any outlying values.

CHAPTER 2 SUMMARY

Concept	Page	Notation / Formula / Description
Categorical data set	29	Consists of observations that may be placed into categories.
Numerical data set	29	Consists of observations that are numbers.
Discrete data set	30	The set of all possible values is finite, or countably infinite.
Continuous data set	30	The set of all possible values is an interval of numbers.
Frequency distribution	33	A table used to describe a data set. It includes the class, frequency, and relative frequency (and cumulative relative frequency, if the data set is numerical).
Class frequency	33	The number of observations within a class.
Class relative frequency	33	The proportion of observations within a class: class frequency divided by total number of observations.

Chapter Summary A table at the end of each chapter provides a list of the main concepts with brief descriptions, proper notation, and applicable formulas, along with page numbers for quick reference.

MEDIA AND SUPPLEMENTS

Macmillan Education LaunchPad

W. H. Freeman's new online homework system, **LaunchPad,** offers our quality content curated and organized for easy assignability in a simple but powerful interface. We've taken what we've learned from thousands of instructors and hundreds of thousands of students to create a new generation of W. H. Freeman/Macmillan technology.

Curated Units. Combining a curated collection of videos, homework sets, tutorials, applets, and e-Book content, LaunchPad's interactive units give instructors building blocks to use as is or as a starting point for their own learning units. Thousands of exercises from the text can be assigned as online homework, including many algorithmic exercises. An entire unit's worth of work can be assigned in seconds, drastically reducing the amount of time it takes to have a course up and running.

Easily customizable. Instructors can customize the LaunchPad Units by adding quizzes and other activities from our vast collection of resources. They can also add a discussion board, a dropbox, and RSS feed, with a few clicks. LaunchPad allows instructors to customize their students' experience as much or as little as they like.

Useful analytics. The Gradebook quickly and easily allows instructors to look up performance metrics for classes, individual students, and individual assignments.

Intuitive interface and design. The student experience is simplified. Students' navigation options and expectations are clearly laid out at all times, ensuring that they can never get lost in the system.

Assets integrated into LaunchPad include:

Interactive e-Book. Every LaunchPad e-Book comes with powerful study tools for students, video and multimedia content, and easy customization for instructors. Students can search, highlight, and bookmark, making it easier to study and access key content. And teachers can ensure that their classes get just the book they want to deliver: customize and rearrange chapters, add and share notes and discussions, and link to quizzes, activities, and other resources.

Macmillan Education LearningCurve provides students and instructors with powerful adaptive quizzing, a gamelike format, direct links to the e-Book, and instant feedback. The quizzing system features questions tailored specifically to the text and adapts to students' responses, providing material at different difficulty levels and topics based on student performance.

Freeman SolutionMaster offers an easy-to-use web-based version of the instructor's solutions, allowing instructors to generate a solution file for any set of homework exercises.

New Stepped Tutorials are centered on algorithmically generated quizzing with step-by-step feedback to help students work their way toward the correct solution. These new exercise tutorials (two to three per chapter) are easily assignable and assessable. Icons in the textbook indicate when a Stepped Tutorial is available for the material being covered.

Statistical Video Series consists of StatClips, StatClips Examples, and Statistically Speaking "Snapshots." View animated lecture videos, whiteboard lessons, and documentary-style footage that illustrate key statistical concepts and help students visualize statistics in real-world scenarios.

New Video Technology Manuals available for TI-83/84 calculators, Minitab, Excel, JMP, SPSS, R, Rcmdr, and CrunchIT! provide brief instructions for using specific statistical software.

Updated StatTutor Tutorials offer multimedia tutorials that explore important concepts and procedures in a presentation that combines video, audio, and interactive features. The newly revised format includes built-in, assignable assessments and a bright new interface.

Updated Statistical Applets give students hands-on opportunities to familiarize themselves with important statistical concepts and procedures, in an interactive setting that allows them to manipulate variables and see the results graphically. These new applets now include a "Quiz Me" function that allows them to be both assignable and assessable. Icons in the textbook indicate when an applet is available for the material being covered.

CrunchIt! is a web-based statistical program that allows users to perform all the statistical operations and graphing needed for an introductory statistics course and more. It saves users time by automatically loading data from the text, and it provides the flexibility to edit and import additional data.

JMP Student Edition (developed by SAS) is easy to learn and contains all the capabilities required for introductory statistics, including pre-loaded data sets from *Introductory Statistics: A Problem-Solving Approach*. JMP is the commercial data analysis software of choice for scientists, engineers, and analysts at companies around the globe (for Windows and Mac).

Stats@Work Simulations put students in the role of the statistical consultant, helping them better understand statistics interactively within the context of real-life scenarios.

EESEE Case Studies (Electronic Encyclopedia of Statistical Examples and Exercises), developed by The Ohio State University Statistics Department, teach students to apply their statistical skills by exploring actual case studies using real data.

Data files are available in ASCII, Excel, TI, Minitab, SPSS (an IBM Company),* and JMP formats.

Student Solutions Manual provides solutions to the odd-numbered exercises in the text. Available electronically within LaunchPad, as well as in print form.

Interactive Table Reader allows students to use statistical tables interactively to seek the information they need.

Instructor's Solutions Manual contains full solutions to all exercises from *Introductory Statistics: A Problem-Solving Approach*. Available electronically within LaunchPad.

Test Bank offers hundreds of multiple-choice questions. Also available on CD-ROM (for Windows and Mac), where questions can be downloaded, edited, and resequenced to suit each instructor's needs.

---

*SPSS was acquired by IBM in October 2009.

Lecture PowerPoint Slides offer a detailed lecture presentation of statistical concepts covered in each chapter of *Introductory Statistics: A Problem-Solving Approach*.

Additional Resources Available with *Introductory Statistics: A Problem-Solving Approach*

Companion Website www.whfreeman.com/introstats2e This open-access website includes statistical applets, data files, and self-quizzes. The website also offers three optional sections covering the normal approximation to the binomial distribution (Section 6.5), polynomial and qualitative predictor models (Section 12.6), and model selection procedures (Section 12.7). Instructor access to the Companion Website requires user registration as an instructor and features all of the open-access student web materials, plus:

- Instructor version of **EESEE** with solutions to the exercises in the student version.
- **PowerPoint Slides** containing all textbook figures and tables.
- **Lecture PowerPoint Slides**
- **Tables and Formulas cards** offer tables, key concepts, and formulas for use as a study tool or during exams (as allowed by the instructor); available as downloadable PDFs.

Special Software Packages Student versions of JMP and Minitab are available for packaging with the text. JMP is available inside LaunchPad at no additional cost. Contact your W. H. Freeman representative for information or visit www.whfreeman.com.

i-clicker is a two-way radio-frequency classroom response solution developed by educators for educators. Each step of i-clicker's development has been informed by teaching and learning. To learn more about packaging i-clicker with this textbook, please contact your local sales rep or visit www.iclicker.com.

ACKNOWLEDGMENTS

I would like to thank the following colleagues who offered specific comments and suggestions on the second-edition manuscript throughout various stages of development:

Jonathan Baker, *Ohio State University*
Andrea Boito, *Penn State Altoona*
Alexandra Challiou, *Notre Dame of Maryland University*
Carolyn K. Cuff, *Westminster College*
Greg Davis, *University of Wisconsin Green Bay*
Richard Gonzalez, *University of Michigan*
Justin Grieves, *Murray State University*
Christian Hansen, *Eastern Washington University*
Christopher Hay-Jahans, *University of Alaska Southeast*
Susan Herring, *Sonoma State University*
Chester Ismay, *Arizona State University*
Ananda Jayawardhana, *Pitt State University*
Phillip Kendall, *Michigan Technological University*
Bashir Khan, *St. Mary's University*
Barbara Kisilevsky, *Queens University*
Tammi Kostos, *McHenry County College*
Adam Lazowski, *Sacred Heart University*
Jiexiang Li, *College of Charleston*
Edgard Maboudou, *University of Central Florida*
Tina Mancuso, *Sage College*
Scott McClintock, *West Chester University*
Jackie Miller, *University of Michigan*
Daniel Ostrov, *Santa Clara University*
William Radulovich, *Florida State College at Jacksonville*
Enayetur Raheem, *University of Wisconsin - Green Bay*
Daniel Rothe, *Alpena Community College*
James Stamey, *Baylor University*
Sunny Wang, *St. Francis Xavier University*
Derek Webb, *Bemidji State University*
Daniel Weiner, *Boston University*
Mark Werner, *University of Georgia*
Nancy Wyshinski, *Trinity College*

A special thanks to Ruth Baruth, Terri Ward, Karen Carson, Cara LeClair, Lisa Kinne, Tracey Kuehn, Julia DeRosa, Vicki Tomaselli, Robin Fadool, Marie Dripchak, Liam Ferguson, Catriona Kaplan, Laura Judge, and Victoria Garvey of W. H. Freeman and Company.

Designer Jerry Wilke and illustrator Cambraia Fernandez, led by Vicki Tomaselli, offered the creativity, expertise, and hard work that went into the design of this new edition.

I am very grateful to Jackie Miller for her insights, suggestions, and editorial talent throughout the production of the second edition. She is doggedly accurate in her accuracy reviews and page proof examination. Thanks to Dennis Free of Aptara for his patience and typesetting expertise. Much appreciated are the copy editing skills brought to the project by Lynne Lackenbach; her time and perseverance helped to add cohesion and continuity to the flow of the material. Many thanks to Aaron Bogan for bringing his attention to detail and knowledge of statistics to the accuracy review of the solutions manuals. And I could not have completed this project without Karen Carson and Leslie Lahr. Both have superb editing skills, a keen eye for style, a knack for eliciting the best from an author, and unwavering support.

My sincere thanks go to the authors and reviewers of the supplementary materials available with *Introductory Statistics: A Problem-Solving Approach*, Second Edition; their hard work, expertise, and creativity have culminated in a top-notch package of resources:

Test Bank written by Julie Clark, Hollins University

Test Bank and iClicker slides accuracy reviewed by John Samons, Florida State College at Jacksonville

Practice Quizzes written by James Stamey, Baylor University

Practice Quizzes accuracy reviewed by Laurel Chiappetta, University of Pittsburgh

iClicker slides created by Paul Baker, Catawba College

Lecture PowerPoints created by Susan Herring, Sonoma State University

I am very grateful to the entire Antoniewicz family for providing the foundation for a wide variety of problems, including those that involve nephelometric turbidity units, floor slip testers, and crazy crawler fishing lures.

I continue to learn a great deal with every day of writing. I believe this kind of exposition has made me a better teacher.

To Joan, thank you for your patience, understanding, inspiration, and tasty treats.

ABOUT THE AUTHOR

Credit: Eric Foster

Steve received his undergraduate degree from Boston College and his M.S. and Ph.D. from the University of New Hampshire. His initial research interests included the statistical analysis of cancer chemoprevention experiments. He has published a number of research papers in mathematics journals, including *Biometrics, Anticancer Research,* and *Computer Methods and Programs in Biomedicine;* presented results at national conferences; and written several books. He has been awarded grants from the National Science Foundation, the Center for Rural Pennsylvania, and the Ben Franklin Program.

Steve is a long-time consultant for the College Board and conducted workshops in Brazil, the Dominican Republic, and China. He was the AP Calculus Chief Reader for four years and has been involved with calculus reform and the use of technology in the classroom. He has been teaching at Bloomsburg University for 25 years and recently served as Director of the Honors Program.

Steve has been teaching introductory statistics classes throughout his academic career, and there is no doubt that this is his favorite course. This class (and text) provides students with basic, lifelong, quantitative skills that they will use in almost any job and teaches them how to think and reason logically. Steve believes very strongly in data-driven decisions and conceptual understanding through problem solving.

Steve's uncle, Fr. Stanley Bezuszka, a Jesuit and professor at Boston College, was one of the original architects of the so-called new math in the 1950s and 1960s. He had a huge influence on Steve's career. Steve helped Fr. B. with test accuracy checks, as a teaching assistant, and even writing projects through high school and college. Steve learned about the precision, order, and elegance of mathematics and developed an unbounded enthusiasm to teach.

INTRODUCTORY STATISTICS

0 Why Study Statistics

The Science of Intuition

In the movie *Erin Brokovich,* actress Julia Roberts plays a feisty, unemployed, single mother of three children. After losing a lawsuit because of her bad behavior in the courtroom, Erin pressures her lawyer Ed Masry, for a job and he conceded. Despite having no legal background, Erin begins working on a real estate case involving Pacific Gas and Electric (PG&E) and the purchase of a home in Hinkley, California.

Erin visits the seller, Donna Jensen, and learns that her husband has Hodgkin's disease and that many Hinkley residents have concerns about the environment. After further investigation, Erin discovers that several residents of Hinkley have suffered from autoimmune disorders and various forms of cancer.

In fact, so many people in Hinkley suffer from similar rare diseases that Erin concludes it could not be a coincidence. This is a very natural, intuitive conclusion, and it is the essence of statistical inference. Erin observed an occurrence that was so rare and extraordinary that she instinctively concluded it could not be due to pure chance or luck. There had to be another reason. Her logic was correct: The unusually high incidence of cancer in Hinkley suggested that something abnormal was happening.

Indeed, PG&E had dumped water contaminated with the chemical chromium 6 into unlined storage pools. The polluted water seeped into the groundwater and eventually into local wells, and many people became ill with various medical problems.

We all have this same natural instinctive reaction when we see something that is extraordinary. Sometimes we think, "Wow, that's incredibly lucky." More often we question the observed outcomes, "There must be some other explanation."

This natural reaction is the foundation of statistical inference. We make these kinds of decisions every single day. We gather evidence, we make an observation, and we conclude that the outcome is either reasonable or extraordinary. The purpose of statistics is simply to quantify this typical, everyday, deductive process. We need to learn about probability so that we know for sure when an outcome is really rare. And we need to study the concepts of randomness and uncertainty.

The most important point here is that this process is not unusual or exceptional. The purpose of this text is to translate this common practice into statistical terms and models. This will make you better prepared to interpret outcomes, draw appropriate conclusions, and assess risk.

s_bukley/Newscom

Here is another example of an extraordinary event involving a daily lottery number. The 1980 Pennsylvania Lottery scandal, or the Triple Six Fix, involved a three-digit daily lottery number. Nick Perry was the announcer for the Daily Number and the plan's architect. With the help of partners, Nick was able to weight all of the balls except for the ones numbered 4 and 6. This meant that the winning three-digit lottery number would be a combination of 4s and 6s. There were thus only eight possible winning lottery numbers, 444, 446, 464, 466, 644, 646, 664, and 666, and the conspirators were certain that the plan would work.

The winning number on the day of the fix was 666. Ignoring the connection to the *Book of Revelations*, lottery officials discovered that there were very unusual betting patterns that day, all on the eight possible lottery numbers involving 4 and 6. This extraordinary occurrence suggested that the unusual bets were not due to pure chance. This conclusion, along with an anonymous tip, helped in a grand jury investigation leading to convictions and jail time for several men.

The Statistical Inference Procedure

The crucial prevailing theme in this text is statistical inference and decision making through problem solving. Computation is important and is shown throughout the text. However, calculators and computers remove the drudgery of hand calculations and allow us to concentrate more on interpretation and drawing conclusions. Most problems in this text contain a part asking the reader to interpret the numerical result or to draw a conclusion.

The process of questioning a rare occurrence or claim can be described in four steps.

Claim: This is the status quo, the ordinary, typical, and reasonable course of events—what we assume to be true.

Experiment: To check a claim, we conduct a relevant experiment or make an appropriate observation.

Likelihood: Here we consider the likelihood of occurrence of the observed experimental outcome, assuming the claim is true. We will use many techniques to determine whether the experimental outcome is a reasonable observation (subject to some variability), or whether it is an exceptionally rare occurrence. We need to consider carefully and quantify our natural reaction to the relevant experiment. Using probability rules and concepts, we will convert our natural reaction to an experimental outcome into a precise measurement.

Conclusion: There are always only two possible conclusions.

1. If the outcome is reasonable, then we cannot doubt the original claim. The natural conclusion is that nothing out of the ordinary is occurring. More formally, there is no evidence to suggest that the claim is false.
2. If the experimental outcome is rare or extraordinary, we usually disregard the lucky alternative, and we think something is wrong. A rare outcome is a contradiction. Strange occurrences naturally make us question a claim. In this case we believe there is evidence to suggest that the claim is false.

Let's try to apply these four steps to the PG&E case in *Erin Brokovich*. The claim or status quo is that the cancer incidence rate in Hinkley is equivalent to the national incidence rate. Recent figures from the American Cancer Society suggest that the cancer incidence rate is approximately 551 in 100,000 for men and 419 in 100,000 for women.[1]

The experiment or observed outcome is the cancer incidence rate for the population living in Hinkley. In the movie, it is implied that Erin counts the number of people in Hinkley who have developed cancer.

Erin determines that the likelihood, or probability, of observing that many people in Hinkley who have developed cancer is extremely low. Subject to reasonable variability, we should not see that many people with cancer in this location.

The conclusion is that this rare event is not due to pure chance or luck. There is some other reason for this rare observation. The implication in the movie is that there is evidence to suggest that something else is affecting the health of the people in Hinkley.

Problem Solving

Perhaps one of the most difficult concepts to teach is problem solving. We all struggle to solve problems: thinking about where to begin, what assumptions we can make, and which rules and techniques to use. One reason many students consider statistics a difficult course is because almost every problem is a word problem. These word problems have to be translated into mathematics.

The Solution Trail in this text is a prescriptive technique and visual aid for problem solving. To decipher a word problem, start by identifying the keywords and phrases. Here are the four steps identified in each Solution Trail for solving many of problems in this text.

1. Find the *keywords*.
2. Correctly *translate* these words in statistics.
3. Determine the applicable *concepts*.
4. Develop a *vision*, or strategy, for the solution.

Many of the examples presented in this text have a corresponding Solution Trail in the margin to aid in problem solving. An example of a Solution Trail appears in the margin. Note that many of these terms and symbols may be unfamiliar to you at this point. Right now, just focus on the idea that the Solution Trial involves keywords, a translation, concepts, and a vision.

The keywords in the problem lead to a translation into statistics. The statistics question is then solved by using the appropriate, specific concepts. The keywords, translation, and concepts are used to develop a grand vision for solving the problem.

This solution technique is not applicable to every problem, but it is most appropriate for finding probabilities through hypothesis testing, which is the foundation of most introductory statistics courses. Some exercises in this text ask you to write each step in the Solution Trail formally. As you become accustomed to using this solution style, it will become routine, natural, and helpful.

Solution Trail

KEYWORDS

- Normally distributed
- Mean
- Standard deviation

TRANSLATION

- Normal random variable
- $\mu = 34$
- $\sigma = 0.5$

CONCEPTS

- Normal probability distribution
- Standardization

VISION

Define a normal random variable and translate each question into a probability statement. Standardize and use cumulative probability associated with Z if necessary.

With a Little Help from Technology

Although it is important to know and understand underlying formulas, their derivations, and how to apply them, we will use and present several different technology tools to supplement problem solving. Your focus should be on the interpretation of results, not the actual numerical calculations.

Four common technology tools are presented in this text.

1. **CrunchIt!** is available in LaunchPad, the publisher's online homework system, and is accessed under the Resources tab. The opening screen (Figure 0.1) looks like a spreadsheet with pull-down menus at the top. You can enter data in columns, Var1, Var2, etc., import data from a file, and export and save data.

   Most Statistics, Graphics, and Distribution Calculator functions start with input screens. Output is displayed in a new screen. Figure 0.2 shows the input screen for a bar chart with summarized data, and Figure 0.3 shows the resulting graph.[2]

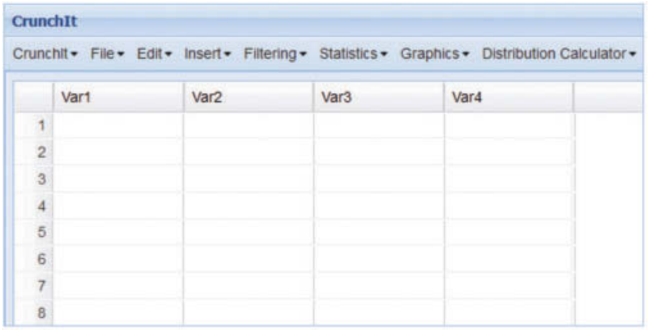


Figure 0.1 CrunchIt! opening screen.

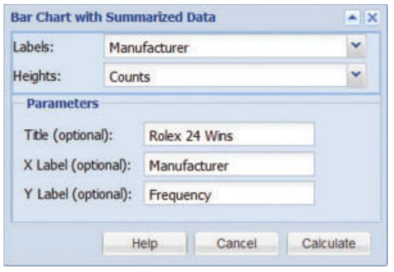


Figure 0.2 Bar chart input screen.

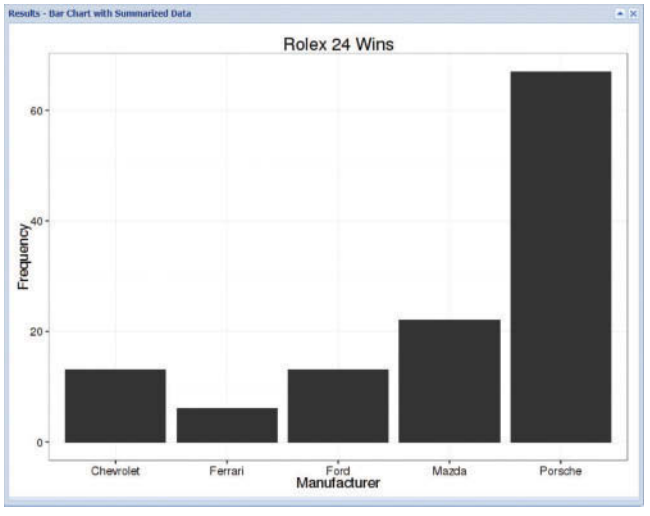


Figure 0.3 CrunchIt! bar chart.

2. The **Texas Instruments TI-84 Plus C** graphing calculator includes many common statistical features such as confidence intervals, hypothesis tests, and probability distribution functions. Data are entered and edited in the stat list editor as shown in Figure 0.4. Figure 0.5 shows the results from a one-sample t test, and Figure 0.6 shows a visualization of this hypothesis test.

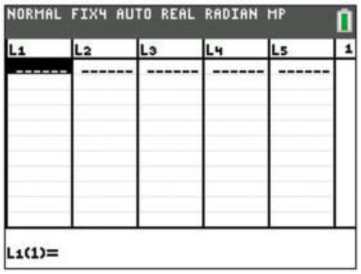


Figure 0.4 The stat list editor.

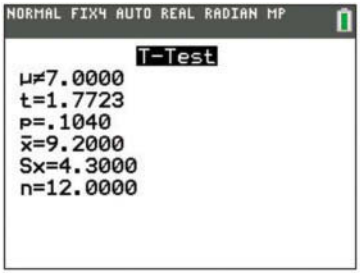


Figure 0.5 One-sample *t*-test output.

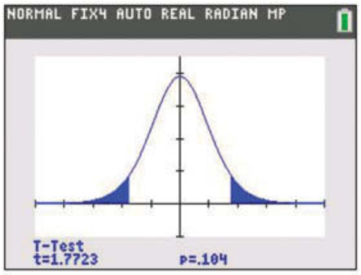


Figure 0.6 One-sample *t*-test visualization.

3. **Minitab** is a powerful software tool for analyzing data. It has a logical interface, including a worksheet screen similar to a common spreadsheet. Data, graph, and statistics tools can be accessed through pull-down menus, and most commands can also be entered in a session window. Figure 0.7 shows a bar chart of the number of Rolex 24 sports car race wins by automobile manufacturer.
4. **Excel 2013** includes many common chart features accessible under the Insert tab. There are also probability distribution functions that allow the user to build templates for confidence intervals, hypothesis tests, and other statistical procedures. The Data Analysis tool pack provides additional statistical functions. Figure 0.8 shows some descriptive statistics associated with the ages of 100 stock brokers at a New York City firm.

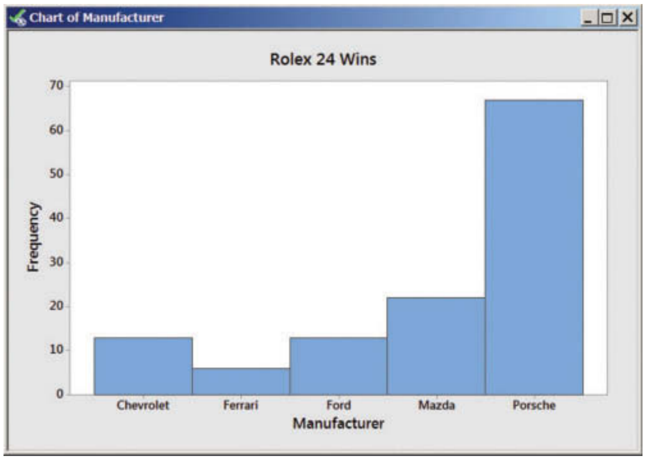


Figure 0.7 Minitab bar chart.

D	E
Age	
Mean	42.7700
Standard Error	0.6543
Median	43
Mode	45
Standard Deviation	6.5426
Sample Variance	42.8052
Kurtosis	-0.5767
Skewness	0.1419
Range	28
Minimum	29
Maximum	57
Sum	4277
Count	100

Figure 0.8 Excel descriptive statistics.

In addition to these tools, JMP statistical software is used by scientists, engineers, and others who want to explore or mine data. Various statistical tools and dynamic graphics are available, and this software features a friendly interactive interface. Figure 0.9 shows a scatter plot of the price of used Honda Accords versus the age of the vehicle, the least-squares regression line, and confidence bands for the true mean price for each age.

Many other technology tools and statistical software packages are also available. For example, R is free statistical software, SPSS is used primarily in the social sciences, and SAS incorporates a proprietary programming language. Regardless of your technology choice, remember that careful and thorough interpretation of the results is an essential part of using software properly.

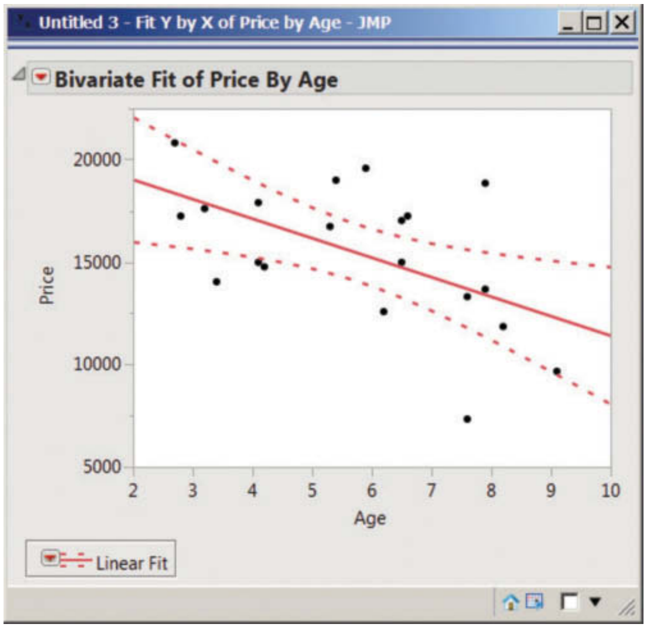


Figure 0.9 JMP scatter plot, regression line, and confidence bands.

CHAPTER 0 EXERCISES

0

0.1 Name the four parts of every statistical inference problem.

0.2 Apply the four statistical inference steps to the Triple Six Fix.

0.3 Name the four parts of the Solution Trail.

0.4 The Canary Party recently began the *Not a Coincidence* campaign to highlight women who have been affected by Merck's human papillomavirus (HPV) vaccine, Gardasil.[3] As of November 2013, a report states that there have been 31,741 adverse events, 10,849 hospitalizations, and 144 deaths due to HPV vaccines. Explain why The Canary Party believes that there must be something wrong with the vaccine.

0.5 It had been very rare for an NBA player to suffer a major knee injury while on the court. Derrick Rose tore an anterior cruciate ligament (ACL) in his left knee in 2012. Rose was the first player to suffer an ACL tear since Danny Manning in 1995 and Bernard King in 1985. Since the injury to Derrick Rose, at least six NBA players have experienced similar injuries—torn ACLs. State two possible explanations for this rare rash of injuries. Which explanation do you think is more plausible? Why?

0.6 In the movie, *Wall Street*, corporate raider Gordon Gekko and his partner Bud Fox made a lot of money trading stocks. However, several of the trades attracted the attention of the Securities and Exchange Commission (SEC). Why do you think the SEC believed Gordon and Bud may have had inside information or manipulated the price of certain stocks?

0.7 What do you think it means when a weatherperson says, "There is a 50% chance of rain today." Contact a weatherperson and ask him or her what this statement means. Does this explanation agree with yours?

0.8 James Bozeman of Orlando won the Florida lotto twice. He beat the odds of 1 in 22,957,480 twice to win a total of $13 million. State two possible explanations for this occurrence. Which explanation do you think is more reasonable? Why?

0.9 In January 2014, 33 whales died off the coast of Florida. Twenty-five were found on Kice Island in Collier County. Blair Mase, a marine mammal scientist with the National Oceanic and Atmospheric Administration (NOAA) indicated that NOAA was carefully investigating these deaths.[4] Explain why NOAA believes the whales did not die as a result of natural causes and is investigating the deaths.

0.10 In January 2014, 62 people became sick after dining at one of two restaurants that share a kitchen in Muskegon County, Michigan.[5] The illnesses occurred over a four-day period, and county health officials began an immediate investigation.

a. Explain why officials investigated the source of these illnesses.

b. Apply the four statistical inference steps to this situation.

0.11 In 2009 and 2010, Toyota issued a costly recall of over 9 million vehicles because of possibly out-of-control gas pedals. There had been at least 60 reported cases of runaway vehicles, some of which resulted in at least one death.[6]

a. State two possible reasons for this observed high number of runaway vehicles.

b. Why do you think Toyota issued this recall?

0.12 Suppose there were 15 home burglaries in a small town during the entire year. None occurred on a Thursday. Do you think there is evidence to suggest that something very unusual is happening on Thursdays in this town to prevent burglaries on this day of the week? Why or why not?

0.13 Recently, the Sedgwick County Health Department reported at least 27 cases of whooping cough in one month. This observed count was more than in any month in the previous five years. Do you think health officials should be concerned about this outbreak of whooping cough? Why or why not?

0.14 To understand the definitions and formulas in this text, you will need to feel comfortable with mathematical notation. To review and prepare for the notation we will use, make sure you are familiar with the following:

a. Subscript notation—for example, $x_1, x_2, \ldots$

b. Summation notation—for example, $\sum_{i=1}^{n} x_i$

c. The definition of a function.

1 An Introduction to Statistics and Statistical Inference

Looking Forward

- Recognize that data and statistics are pervasive and that statistics are used to describe typical values and variability, and to make decisions that affect everyone.
- Understand the relationships among a population, a sample, probability, and statistics.
- Learn the basic steps in a statistical inference procedure.

Is it safe to eat rice?

Arsenic is a naturally occurring element that is found mainly in the Earth's crust. Some people are exposed to high levels of arsenic in their jobs, or near hazardous waste sites, or in some areas of the country in which there are high levels of arsenic in the surrounding soil, rocks, or even water. Exposure to small amounts of arsenic can cause skin discoloration, and long-term exposure has been associated with higher rates of some forms of cancer. Excessive exposure can cause death.

In 2012, the U.S. Food and Drug Administration (FDA) and *Consumer Reports* announced test results that revealed many brands of rice contain more arsenic in a single serving than is allowed by the Environmental Protection Agency (EPA) in a quart of drinking water.[1] Trace amounts of arsenic may also be found in flour, juices, and even beer. Earlier in that year, a study conducted at Dartmouth College detected arsenic in cereal bars and infant formula.

The FDA has established a safe level of arsenic in drinking water, 10 parts per billion (ppb). However, there is no equivalent safe maximum level for food. Suppose the FDA is conducting an extensive study to determine whether to issue any warnings about rice consumption. One hundred random samples of rice are obtained, and each is carefully measured for arsenic.

The methods presented in this chapter will enable us to identify the population of interest and the sample, and to understand the definition and importance of a random sample. Most important, we will characterize the deductive process used when an an extraordinary event is observed and cannot be attributed to luck.

CONTENTS

wanphen chawarung/Shutterstock