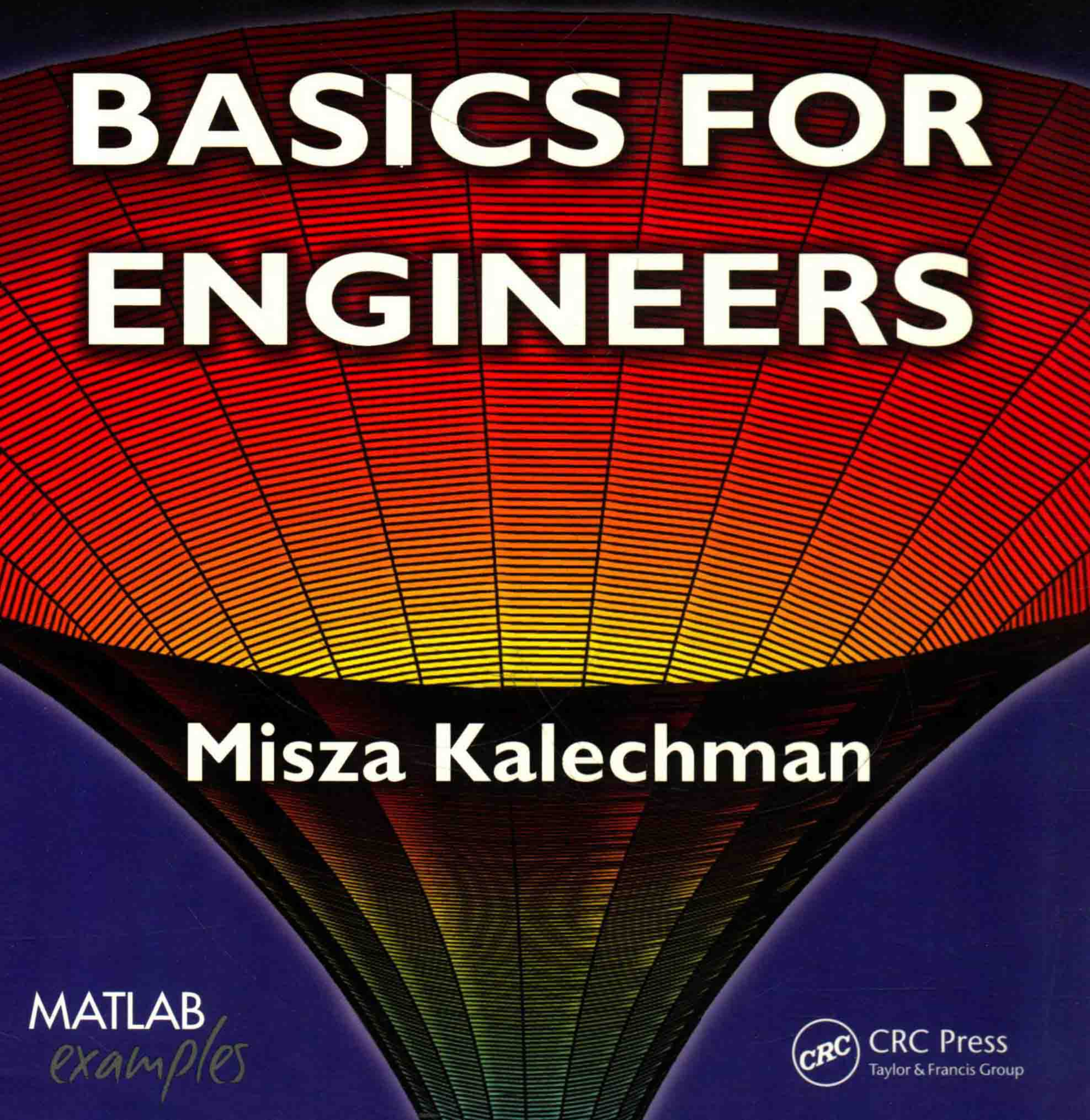
Practical MATLAB® for Engineers

PRACTICAL MATLAB® BASICS FOR ENGINEERS



Misza Kalechman

MATLAB examples

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PRACTICAL MATLAB®
BASICS FOR ENGINEERS

Handbook of Practical MATLAB® for Engineers

Practical MATLAB® Basics for Engineers

Practical MATLAB® Applications for Engineers

Preface

Practical MATLAB® Basics for Engineers is a simple, easy-to-read, introductory book of the basic mathematical concepts and principles, using the MATLAB® language to illustrate and evaluate numerical expressions and data visualization of large classes of functions and problems, written for beginners with no previous knowledge of MATLAB. MATLAB is a registered trademark of The MathWorks, Inc. For product information, please contact

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Once the mathematical concepts are introduced and understood by the reader, MATLAB is then used in *Practical MATLAB® Applications for Engineers* in the analysis and synthesis of engineering and technology problems, for the case of continuous and discrete time systems.

MATLAB is a powerful, comprehensive, user-friendly, and interactive software package that is gaining acceptance as the ideal computational choice for scientists and engineers and is becoming an industrial standard, used to solve a wide range of problems in other diverse areas such as economics, business, technology, engineering, science, and education.

The reason that MATLAB has replaced other technical computational languages is that MATLAB is based on simple and easy-to-use programming tools, graphic facilities, built-in functions, and an extensive number of toolboxes.

Each chapter of this book is self-contained, in the sense that a serious attempt was made to provide the reader with all the theoretical concepts required to fully understand each chapter's material using simple numerical examples as well as direct language.

The idea is that with a relatively smaller set of functions, the reader can begin to write programs. Each chapter contains in addition a number of worked-out examples, systematically solved and chosen to illustrate general types of solutions to classes of problems often encountered in industry and academia.

The only thing that this book requires from the reader is an open and logical mind, basic skills, common sense, and academic maturity equivalent to those in the first year of college in science, technology, engineering, or a senior at a technical high school.

In summary, an effort has been made to accomplish the following goals and objectives:

- To provide reasonable proficiency in a relatively short time
- To be practical
- To introduce concepts in a compact, simple, and direct way
- To teach core skills that will aid the reader in the classroom and careers
- To be easy to read and understand, friendly, and interesting
- To provide many numerical and worked-out examples
- To be self-contained with little or no outside assistance

- To be organized by topics and complexity
- To be a valuable resource to
  - The engineering and technology student
  - The professional engineering student (preparing for the PE license)
  - The technical consultant
  - The practicing engineer

Author

Misza Kalechman is a professor of electrical and telecommunication engineering technology at New York City College of Technology, part of the City University of New York.

Mr. Kalechman graduated from the Academy of Aeronautics (New York), Polytechnic University (BSEE), Columbia University (MSEE), and Universidad Central de Venezuela (UCV; electrical engineering).

Mr. Kalechman was associated with a number of South American universities where he taught undergraduate and graduate courses in electrical, industrial, telecommunication, and computer engineering; and was involved with applied research projects, designs of laboratories for diverse systems, and installations of equipment.

He is one of the founders of the Polytechnic of Caracas (Ministry of Higher Education, Venezuela), where he taught and served as its first chair of the Department of System Engineering. He also taught at New York Institute of Technology (NYIT); Escofa (officers telecommunication school of the Venezuelan armed forces); and at the following South American universities: Universidad Central de Venezuela, Universidad Metropolitana, Universidad Catolica Andres Bello, Universidad the Los Andes, and Colegio Universitario de Cabimas.

He has also worked as a full-time senior project engineer (telecom/computers) at the research oil laboratories at Petroleos de Venezuela (PDVSA) Intevep and various refineries for many years, where he was involved in major projects. He also served as a consultant and project engineer for a number of private industries and government agencies.

Mr. Kalechman is a licensed professional engineer of the State of New York and has written *Practical MATLAB for Beginners* (Pearson), *Laboratorio de Ingenieria Electrica* (Alpi-Rad-Tronics), and a number of other publications.

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Trends, the Industry, and MATLAB®

> Unless you try to do something beyond what you have already mastered, you will never grow.*
>
> **Ralph Waldo Emerson**

1.1 Introduction

In this chapter, a general look is taken at the computer, field of computing, skills associated with computer programming and computer languages, problem solving and algorithms, as well as economic shifts produced by the changes in technology that are having an impact on the world around us, job market, and of course our lives.

Obviously everyone has their own opinion about the world around them. This opinion is shaped by background, education, values, and above all by experiences.

> We don't see things as they are, we see them as we are.*
>
> **Anais Nin**

The main objective of this book is to attempt to see things as they are. Some see technology as a "graying industry," but others see it as opportunities especially when computing technology focuses less on the tools of technology and more on how technology is used in the search for scientific breakthroughs, the development of new products and services, or the way work is done.

Presently, it is universally accepted that computers are an essential tool of the educational process in the technologies, humanities, sciences and engineering, as well as industries and business. The computer has changed our lives: the way we study, work, and do business.

Bill Gates, the cofounder and chairman of Microsoft, summarized his view of the computing field by saying

> We are on the threshold of extraordinary advances in computing that will affect not only the sciences but also how we work and our culture.
>
> We need to get the brightest people working on those opportunities.

The meaning of computing has also changed over the last decades. Let us analyze some of the changes and trends.

* O'Brien, M.J. and Lary, S., *Profit from Experience*, Bard & Stephen, Austin, TX, 1995.

There was a time, not long ago, when the word *computer* was a job description associated with special people, with strong analytical minds, who performed tedious mathematical calculations for huge military and engineering projects.

With the passing of time, *computers* evolved and became more associated with machine languages, compilers, and tables of numbers.

Computers today are known as machines that perform symbolic computations, animation, graphics, interactive calculations, and act as an intelligent communication device, replacing in many instances the plain old telephone (pot).

The modern computer is based on the original model developed by John von Neumann back in 1952. He recognized that the real power of the computer is based on simple logical operations, binary in nature, which executed one instruction at a time in strict serial order at fantastic speeds. Today's computers can perform multiprocessing or parallel computations, and information can be received from a number of sources such as other computers or communication devices or systems through the Internet, or the World Wide Web.

A few words about the Web. The Web is a medium that has the potential to provide universal access to information for almost everyone, independent of boundaries, cultures, and locations. The Web is the most important part of the Internet. The Internet is a worldwide network of computers, owned and supervised by no particular entity or agency or more directly stated by no one. The Internet was originally developed by the U.S. Department of Defense, in 1969, under the project name of Advanced Research Project Agency Network (Arpanet) whose main research objective was to keep the U.S. military sides communicated in the event of a nuclear war. Its first test and practical application was to serve as a communication medium among nuclear physicists located in dispersed and distant geographic locations, employing a variety of communication systems and devices. This first test was performed by the European Particle Laboratory, part of a larger organization known as European Organization for Nuclear Research (CERN). From the early days, in March 1989 (led by Tim Berners-Lee, an Oxford graduate student) engineers recognized the importance of finding a simple and efficient solution to the communication problem of large, geographically extended organizations.

The same needs exist in private and government organizations, such as banks, hospitals, insurance and investment corporations, airline and oil companies, as well as government agencies such as law enforcement, military, education, and health.

The communication and information revolution of the last decades of the twentieth century was centered on the computer and the Internet. This revolution started in the early 1950s with the development of the solid-state transistor and will probably continue well into the twenty-first century.

As the devices and technologies improved over the last half-century (1960–2008), so did productivity, quality of life, and industrial competitiveness, creating new jobs and economic opportunities.

Understanding today's technologies is the basis for learning tomorrow's technologies, applications, and business opportunities. Computing is almost an infinitely malleable and universal tool. Software can be programmed to do all manner of tasks and is continuously being improved. So, computing is more like biology; it evolves unlike traditional industrial technologies such as steam, electricity, and the internal combustion engine. For example, deoxyribonucleic acid (DNA) codes that contain the secrets of life and evolution can be explored and simulated using computer codes.

Disciplines as diverse as weather forecasting, oil exploration, drug research and marketing, drug side effects, and chemical analysis rely heavily on computers and computer simulation. Even the entertainment industry (sound and video) and modern automobiles are largely controlled and monitored by a network of microprocessors and software. Today's automobile is commonly referred to as a computer on wheels.

The computer and the network it is connected to is as powerful as the software it uses. This book deals with one such software package named MATLAB that is gaining acceptance in the scientific and business communities.

The Matrix Laboratory package referred to as MATLAB was originally designed to serve as the interactive link to the numerical computation libraries LINPACK and EISPACK that were used by engineers and scientists when they were dealing with sets of equations.

Today, MATLAB is a computer language designed for technical computing, mathematical analysis, and system simulation. It is interactive in nature and is specifically designed to solve problems in the engineering fields, sciences, and business applications, and appears to be evolving as the preferred tool in the processes of engineering analysis and synthesis.

The MATLAB software was originally developed at the University of New Mexico and Stanford University in the late 1970s. By 1984, a company was established named as Matwork by Jack Little and Cleve Moler with the clear objective of commercializing MATLAB. Over a million engineers and scientists use MATLAB today in well over 3000 universities worldwide and it is considered a standard tool in education, business, and industry.

The basic element in MATLAB is the matrix, and unlike other computer languages it does not have to be dimensioned or declared.

MATLAB's original objective was to be the tool to solve mathematical problems in linear algebra, numerical analysis, and optimization; but it quickly evolved as the preferred tool for data analysis, statistics, signal processing, control systems, economics, weather forecast, and many other applications. Over the years, MATLAB evolved creating an extended library of specialized built-in functions that are used to generate among other things two-dimensional (2-D) and 3-D graphics and animation and offers numerous supplemental packages called toolboxes that provide additional software power in special areas of interest such as

- Curve fitting
- Optimization
- Signal processing
- Image processing
- Filter design
- Neural network design
- Control systems
- Statistics

Why is MATLAB becoming the standard in industry, education, and business? The answer is that the MATLAB environment is user-friendly and the objective of the software is to spend time in learning the physical and mathematical principles of a problem and not about the software. The term *friendly* is used in the following sense: the MATLAB software executes one instruction at a time. By analyzing the partial results and based on these results, new instructions can be executed that interact with the existing information already stored in the computer memory, without the formal compiling required by other competing high-level computer languages.

This interactive environment between the machine and the user is particularly important in the solution of problems in which the information at one point of the process may be the guide to the next step in the solution of a particular problem. This computation environment is probably the one that a new engineer, technologist, or technician is most likely to encounter in tomorrow's industries.

1.2 The Job Market

Today, the key to economic growth and economic survival of regions and nations is to have an adequate number of well-trained engineers, technologists, and technicians to support the society's industrial and commercial infrastructure.

To identify technical areas of growth that may impact the job market, some of the present global economic conditions and trends are identified and discussed first.

In 2004, the total U.S. job market exceeded 131 million, with a huge service sector, which now employs more than 80% of America's workers. The U.S. economy needs to add 2–3 million jobs annually, just to keep unemployment at a reasonable healthy level.

An estimated 35–40% of the new jobs are in the electronic-telecommunication-computer area, and nearly 3.5 million are employed as information technology professionals (2004). The U.S. government is a big employer and can add large numbers of jobs to the market depending on political (security, terrorism, etc.) and global conditions (agreements, wars, intervention, conflicts, disasters, etc.).

In 2003, the (U.S.) federal government employed 1.9 million civilian workers, 1.5 million in the military, and 800,000 in the postal service, which brought the total number employed by the federal government to 4.2 million, equal to 3% of the total (U.S.) job market. Government policies such as taxes, interest rates, trade agreements, economic indexes (such as consumer and confidence), and foreign competition may also have an effect on the economy and of course the job market.

1.3 Market and Labor Trends

Some market and labor trends are summarized below:

a. The general economic and job conditions, according to the U.S. Department of Labor, is that more than 1 million jobs of the 1.2 million jobs created in the period 1999–2004 are part-time or temporary (*The New York Times*, October 10, 2004).

   It can be safely stated that job trends are driven by part-time and temporary employment. The main reason for this is probably the cost of labor benefits usually paid to full-time employees.

   In 2003, there were 25 million part-time workers in the United States and from this figure, only 4.8 million had some kind of benefits.

   The trends indicate that part-time jobs would represent approximately 20% of the overall job market in the United States.

b. Today's market trends can be summarized by a simple sentence—*do more with less*, which means that the use of technology (computerized and intelligent systems) will increase, whereas union jobs and job security in general will be on the decline.

c. The Fortune 500 American companies have been downsizing and outsourcing for the past 30 years. Meanwhile, small and midsize firms have been growing much more rapidly. The result is that the labor force must be much more flexible and able to adjust to rapid changes.

d. Clearly, the U.S. economy is moving the job market away from industries that export or compete with imports, especially manufacturing, to industries that are insulated from foreign competition, such as housing and health. Since 2000, almost 3 million jobs in the manufacturing areas were lost, whereas membership in the National Association of Realtors has risen 50%.

e. In the technologies, for example, the leap from copper to optical fiber (from 1998 to 2003) eliminated 15.5% of the cable jobs. But the new fiber jobs paid 26% more than those in the cable industry and employment grew at 22.6%, according to the Economic Policy Institute (a Washington-based research center), whereas the total number of telecommunication workers represented by unions has fallen 23% since 2000 (Bureau of Labor Statistics).

f. After years of encouraging workers to take early retirement as a way to cut jobs, a growing number of American companies are hunting for older workers because they have lower turnover rate and in many cases better job performance.

   Some statistics may illustrate this point—in the 65–69 age group, about one-third of men and almost one-fourth of women were working in 2004.

   In activities like nursing where statistics are available, the following occurred: In 2002–2003, hospitals raised pay scales and hired 130,000 nurses over the age of 50, which makes up more than 70% of the 185,000 hired in these years.

g. The only way that labor can squeeze out more efficiency is by evolving, which means that people have to learn more than one job in their career even if they stay with the same company.

h. Statistical data supports the economic expert's finding that a new worker (a recent graduate) should expect not just four or five job changes over a lifetime, but four or five different careers over a lifetime.

i. The job market trend indicates increases in
   - Self-employment
   - Home office and online jobs
   - Contract work
   - Temporary or contingent work
   - Consulting

j. Job market trends also indicate decreases in services and technology, in the form we are accustomed to. The reasons for the decline are partially due to shifts in the technologies and trade, which is addressed later in this section. Clearly, the job market rewards people that possess individual talent. Higher education pays off because it provides technical knowledge and filters out people who have organizational skills, discipline, self-motivation, and social adeptness.

k. Furthermore, trade and technology are rapidly transforming the service economy, as we traditionally know it. The United States as well as the global economy is in a transition period and it will surely adjust over time to the new realities, creating new sources of work that will employ new workers with new skills and talents.

l. Statistical data and economic studies indicate that foreign competition and outsourcing (from China, India, etc.) are having a growing impact on the U.S. global economy and will surely affect the job markets in the coming decades.

m. According to the Kaiser Foundation "globalization of manufacturing means that more manufacturing and service related industries are outsourced." Obviously, the reason for outsourcing and moving abroad is not just to find lower wages and keep operating costs down, but also to get smart, dedicated workers and in many cases better infrastructure.

   The overseas worker is generally well educated and trained, focused and efficient, and receives generally a lower salary and little or no benefits.

   Why should any employer, anywhere in the world, hire American workers if other people, just as well educated, are available for half the wages or less?

n. No one knows with precision how many jobs are leaving the United States. Government estimates are

   i. 102,000 in 2003

   ii. 143,000 in 2004

   Unless someone abolishes the Internet and global economic integration, it will be hard to stop and reverse this trend.

o. A few words about foreign competition using India as an example. India's service industry posted $12.3 billion in export revenues in the year ending 2004, a 30% rise over the previous year. India's outsourcing industry employed over 800,000 employees and its growth is estimated to be 30–40% per year. General Electric and City Group are some of the American corporations that use India's outsourcing industry. The leading outsourcing companies in India earned as much as two-thirds of their revenues from U.S. customers (*The New York Times*, November 4, 2004). Of course, India is not an isolated case. Identical problems are faced by the U.S. economy from competing countries in all five continents.

p. According to the Bureau of Labor Statistics, outsourcing is responsible for 1.9% of layoffs in the United States. Economic experts predict that the efficiencies due to outsourcing will create more jobs at better wages than the ones destroyed (Brooks, 2007; Lohr, 2007). Over the years, the H-1 visa that allows a person to work in the United States for 3 years and be renewed for an additional 3 years has been used by U.S. companies to recruit the brightest workers from around the world. The current visa cap (2007) is 65,000, which poses a serious challenge to the U.S. job market. Meanwhile, the outsourcing market is estimated to be in the order of $386 billion in 2007 and growing with high-quality talents from eastern and central Europe like Poland, Hungary, the Czech Republic, and Slovakia with an estimated outsourcing business of $2 billion in 2007 and an expected growth rate of 30% by 2010, compared with 25% for the global market (Tagliabue, 2007).

q. The old line of U.S. companies, the last bastion of fully paid employee benefits are struggling in the global market, and few can afford to pay 100% of worker's health insurance premiums. The number of individual premiums plummeted from 29% in 2000 to 17% in 2004, and family health coverage premiums paid by private companies dropped from 11% in 2000 to 6% in 2004.

r. Some figures about costs of health benefits are provided as follows to give some insight to the magnitude of the problem facing the American manufacturing and service industries. For example, General Motors (GM), the largest private purchaser of health services, spent an estimated $4.8 billion a year with earnings of only $1.2 billion to provide health coverage to all employees (active and 400,000 retirees and dependents). At GM, each U.S. worker has to support 2.5 retirees, adding an average of $2200 to the price of each vehicle ($1625 on health care and $675 on pension), whereas its market share has declined steadily since 1996.

Toyota, with profits of $10.2 billion, which is more than double the combined profit of the big three (GM, Ford, and Daimler-Chrysler), reported that the health care obligations are not large enough to affect in any significant way its profits (*The New York Times*, October 25, 2004).

s. GM, which does set aside money for future retiree benefits, has reported (*The New York Times*, July 25, 2005) that the sum of its health care promised to retirees was $77.47 billion in 2004, which is $9.93 billion up from 2003.

t. GM is not an isolated case. Boeing, which estimated its retiree health and other nonpension obligations at $8.14 billion at the end of 2004, has assets of less than $100 million to cover them.

u. Because of the soaring cost of health care coverage, an estimated 40% of companies with more than 5000 employees no longer offer retiree health benefits.

v. In the 3-year period of 2002–2005, profits at the seven largest companies in the Silicon Valley area, the nation's high technology heartland, increased by an average of 500%, whereas employment has declined.

The increase in profits is dramatic. These actions are driven in part by the automation that Silicon Valley has largely made possible, allowing companies to create more value with fewer workers, keeping a brain trust of creative people, managers, and engineers in the United States, and hiring workers for lower level tasks elsewhere (*The New York Times*, July 3, 2005).

w. An analysis published in the San Jose Mercury News found that the top 100 public companies in the Silicon Valley (Stross, 2006)* region had revenues of $336 billion in 2004, an increase of 14% from the previous year, clearly indicating a high productivity (profits and sales) jobless trend.

1.4 Technical Know-How: Trends and Facts

Some facts and trends about technical knowledge are summarized as follows:

- Human knowledge is doubling every 10 years.
- In the past decade (1995–2005), more scientific knowledge was created than in all human history.
- Computational power based on powerful microprocessors is doubling every 18–24 months.
- A weekend edition of *The New York Times* contains more information than the average person was likely to come across in a lifetime during the seventeenth century in England.

* One-third of all venture investment deals went to the San Francisco Bay area. This number has not changed for the past 10 years. The New England region is far behind at 10%.