

Applications

53. ● **Revenue** Your T-shirt operation is doing a booming trade. Last week you sold 50 tie-dye shirts for \$15 each, 40 Suburban State University Crew shirts for \$10 each, and 30 Lacrosse T-shirts for \$12 each. Use matrix operations to calculate your total revenue for the week. *hint* [see Example 1]
54. ● **Revenue** Karen Sandberg, your competitor in Suburban State U's T-shirt market, has apparently been undercutting your prices and outperforming you in sales. Last week she sold 100 tie dye shirts for \$10 each, 50 (low quality) Crew shirts at \$5 apiece, and 70 Lacrosse T-shirts for \$8 each. Use matrix operations to calculate her total revenue for the week.
55. ● **Revenue** Recall the Left Coast Bookstore chain from the preceding section. In January, it sold 700 hardcover books, 1300 softcover books, and 2000 plastic books in San Francisco; it sold 400 hardcover, 300 softcover, and 500 plastic books in Los Angeles. Now, hardcover books sell for \$30 each, softcover books sell for \$10 each, and plastic books sell for \$15 each. Write a column matrix with the price data and show how matrix multiplication (using the sales and price data matrices) may be used to compute the total revenue at the two stores. *hint* [see Example 5]
56. ● **Profit** Refer back to Exercise 55, and now suppose that each hardcover book costs the stores \$10, each softcover book

costs \$5, and each plastic book costs \$10. Use matrix operations to compute the total *profit* at each store in January.

57. ● **Publishing** Editors' workloads were increasing during the 1990's, as the following table shows.⁷

	1993	1994	1995	1996
Books per Editor	3	3.5	5	5.2
Number of Editors	16,000	15,000	12,500	13,000

Use matrix multiplication to estimate the total number of books published during the years 1993–1996.

58. ● **Real Estate** The following table shows the cost of one square foot of residential real estate, in dollars per square foot, at the start of 2003⁸ together with the number of square feet your development company intends to purchase in each city.

	New York	London	Hong Kong
Cost per sq. foot	760	800	300
Number of sq. ft	500	800	1000

Use matrix multiplication to estimate the total cost of the real estate.

tech **Ex Income** Exercises 59–62 are based on the following Excel sheet, which shows the 2004 and 2005 male and female population in various age groups, as well as per capita incomes.⁹

	A	B	C	D	E	F	G
1			2004 Population		2005 Population		
2	Age	Mean Income (\$1000)	Female (Millions)	Male (Millions)	Female (Millions)	Male (Millions)	
3							
4	15 to 24	12.5	20	21	20	21	
5	25 to 34	31.7	19	18	19	18	
6	35 to 44	40.4	22	21	22	21	
7	45 to 54	43.0	21	21	21	20	
8	55 to 64	38.0	16	14	15	14	
9	65 to 74	25.2	42	42	42	42	
10							
11							

59. ● Use matrix algebra to estimate the total income for females in 2004. (Round the answer to two significant digits.)
60. ● Use matrix algebra to estimate the total income for males in 2005.

⁷ Books per Editor refers to new titles. Data are rounded. SOURCES: R.R. Bowker, EEOC/The New York Times, June 29, 1998, p. E1.

⁸ Figures are rounded. SOURCE: CLSA, Honk Kong Monetary Authority/New York Times, August 15, 2003, p. C1.

⁹ The population figures are Census Bureau estimates, and the income figures are 2001 mean per capita incomes. All figures are rounded. SOURCE: U.S. Census Bureau www.census.gov.

61. ● Give a single matrix formula that expresses the difference in total income between males and females in 2005, and compute its value, rounded to two significant digits.
62. ● Give a single matrix formula that expresses the total income in 2005, and compute its value, rounded to two significant digits.
63. ● **Cheese Production** The total amount of cheese, in billions of pounds, produced in the 13 western and 12 north central U.S. states in 1999 and 2000 was as follows.¹⁰

	1999	2000
Western States	2.7	3.0
North Central States	3.9	4.0

Thinking of this table as a (labeled) 2×2 matrix P , compute the matrix product $[-1 \ 1]P$. What does this product represent?

64. ● **Milk Production** The total amount of milk, in billions of pounds, produced in the 13 western and 12 north central U.S. states in 1999 and 2000 was as follows.¹¹

	1999	2000
Western States	56	60
North Central States	57	59

Thinking of this table as a (labeled) 2×2 matrix P , compute the matrix product $P \begin{bmatrix} -1 \\ 1 \end{bmatrix}$. What does this product represent?

Bankruptcy Filings Exercises 65–70 are based on the following chart, which shows the number of personal bankruptcy filings in three New York/New Jersey regions during various months of 2001–2002.¹²

	Jan 01	Jul 01	Jan 02
Manhattan	150	150	150
Brooklyn	300	300	250
Newark	250	250	200

65. Each month, your law firm handles 10% of all bankruptcy filings in Manhattan, 5% of all filings in Brooklyn, and 20% of all filings in Newark. Use matrix multiplication to compute the total number of bankruptcy filings handled by your firm in each of the months shown.

¹⁰ Ibid.

¹¹ Figures are approximate. SOURCE: Department of Agriculture/*New York Times*, June 28, 2001, p. C1.

¹² Data are approximate four-week moving averages. SOURCE: Lundquist Consulting/*New York Times*, February 10, 2002, p. L1.

tech Ex technology exercise

66. Your law firm handled 10% of all bankruptcy filings in each region in January 2001, 30% of all filings in July 2001, and 20% of all filings in January 2002. Use matrix multiplication to compute the total number of bankruptcy filings handled by your firm in each of the regions shown.

67. Let A be the 3×3 matrix whose entries are the figures in the table, and let $B = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix}$. What does the matrix BA represent?

68. Let A be the 3×3 matrix whose entries are the figures in the table, and let $B = \begin{bmatrix} 1 & 1 & 0 \end{bmatrix}^T$. What does the matrix AB represent?

69. Write a matrix product whose computation gives the total number by which the combined filings in Manhattan and Newark exceeded the filings in Brooklyn.

70. Write a matrix product whose computation gives the total number by which bankruptcy filings in January, 2001, exceeded filings in January, 2002.

71. **Costs** Microbucks Computer Co. makes two computers, the Pomegranate II and the Pomegranate Classic. The Pom II requires 2 processor chips, 16 memory chips, and 20 vacuum tubes, while the Pom Classic requires 1 processor chip, 4 memory chips, and 40 vacuum tubes. There are two companies that can supply these parts: Motorel can supply them at \$100 per processor chip, \$50 per memory chip, and \$10 per vacuum tube, while Intola can supply them at \$150 per processor chip, \$40 per memory chip, and \$15 per vacuum tube. Write down all of this data in two matrices, one showing the parts required for each model computer, and the other showing the prices for each part from each supplier. Then show how matrix multiplication allows you to compute the total cost for parts for each model when parts are bought from either supplier.

72. **Profits** Refer back to Exercise 71. It actually costs Motorel only \$25 to make each processor chip, \$10 for each memory chip, and \$5 for each vacuum tube. It costs Intola \$50 per processor chip, \$10 per memory chip, and \$7 per vacuum tube. Use matrix operations to find the total profit Motorel and Intola would make on each model.

73. **Tourism** The following table gives the number of people (in thousands) who visited Australia and South Africa in 1998.¹³

To	Australia	South Africa
From North America	440	190
Europe	950	950
Asia	1790	200

¹³ Figures are rounded to the nearest 10,000. SOURCES: South African Dept. of Environmental Affairs and Tourism; Australia Tourist Commission/*The New York Times*, January 15, 2000, p. C1.

● basic skills ◆ challenging

You estimate that 5% of all visitors to Australia and 4% of all visitors to South Africa decide to settle there permanently. Take A to be the 3×2 matrix whose entries are the 1998 tourism figures in the above table and take

$$B = \begin{bmatrix} 0.05 \\ 0.04 \end{bmatrix} \quad \text{and} \quad C = \begin{bmatrix} 0.05 & 0 \\ 0 & 0.04 \end{bmatrix}$$

Compute the products AB and AC . What do the entries in these matrices represent?

74. ● **Tourism** Referring to the tourism figures in the preceding exercise, you estimate that from 1998 to 2008, tourism from North America to each of Australia and South Africa will have increased by 20%, tourism from Europe by 30%, and tourism from Asia by 10%. Take A to be the 3×2 matrix whose entries are the 1998 tourism figures and take

$$B = \begin{bmatrix} 1.2 & 1.3 & 1.1 \end{bmatrix} \quad \text{and} \quad C = \begin{bmatrix} 1.2 & 0 & 0 \\ 0 & 1.3 & 0 \\ 0 & 0 & 1.1 \end{bmatrix}$$

Compute the products AB and AC . What do the entries in these matrices represent?

75. ◆ **tech** Ex **Population Movement** In 2003, the population of the U.S., broken down by regions, was 53.3 million in the Northeast, 64.0 million in the Midwest, 101.6 million in the South, and 65.4 million in the West.¹⁴ The matrix P below shows the population movement during the period 2003–2004. (Thus, 98.79% of the population in the Northeast stayed there, while 0.20% of the population in the Northeast moved to the Midwest, and so on.)

$$P = \begin{matrix} & \begin{matrix} \text{To} & \text{To} & \text{To} & \text{To} \\ \text{NE} & \text{MW} & \text{S} & \text{W} \end{matrix} \\ \begin{matrix} \text{From NE} \\ \text{From MW} \\ \text{From S} \\ \text{From W} \end{matrix} & \begin{bmatrix} 0.9879 & 0.0020 & 0.0081 & 0.0019 \\ 0.0014 & 0.9895 & 0.0063 & 0.0028 \\ 0.0027 & 0.0025 & 0.9927 & 0.0022 \\ 0.0010 & 0.0030 & 0.0050 & 0.9909 \end{bmatrix} \end{matrix}$$

Set up the 2003 population figures as a row vector. Then use matrix multiplication to compute the population in each region in 2004. (Round all answers to the nearest 0.1 million.)

51. ● **Nutrition** A four-ounce serving of Campbell's® Pork & Beans contains 5 grams of protein and 21 grams of carbohydrates.¹⁶ A typical slice of "lite" rye bread contains 4 grams of protein and 12 grams of carbohydrates.

- I am planning a meal of "beans-on-toast" and I want it to supply 20 grams of protein and 80 grams of carbohydrates. How should I prepare my meal?
- If I require A grams of protein and B grams of carbohydrates, give a formula that tells me how many slices of bread and how many servings of Pork & Beans to use.

52. ● **Nutrition** According to the nutritional information on a package of Honey Nut Cheerios® brand cereal, each 1-ounce serving of Cheerios contains 3 grams protein and 24 grams carbohydrates.¹⁷ Each half-cup serving of enriched skim milk contains 4 grams protein and 6 grams carbohydrates.

- I am planning a meal of cereal and milk and I want it to supply 26 grams of protein, and 78 grams of carbohydrates. How should I prepare my meal?
- If I require A grams of protein and B grams of carbohydrates, give a formula that tells me how many servings of milk and Cheerios to use.

53. ● **Resource Allocation** You manage an ice cream factory that makes three flavors: Creamy Vanilla, Continental Mocha, and Succulent Strawberry. Into each batch of Creamy Vanilla go two eggs, one cup of milk, and two cups of cream. Into each batch of Continental Mocha go one egg, one cup of milk, and two cups of cream. Into each batch of Succulent Strawberry go one egg, two cups of milk, and one cup of cream. Your stocks of eggs, milk, and cream vary from day to day. How many batches of each flavor should you make in order to use up all of your ingredients if you have the following amounts in stock?

- 350 eggs, 350 cups of milk, and 400 cups of cream
- 400 eggs, 500 cups of milk, and 400 cups of cream
- A eggs, B cups of milk, and C cups of cream

54. ● **Resource Allocation** The Arctic Juice Company makes three juice blends: PineOrange, using 2 quarts of pineapple juice and 2 quarts of orange juice per gallon; PineKiwi, using 3 quarts of pineapple juice and 1 quart of kiwi juice per gallon; and OrangeKiwi, using 3 quarts of orange juice and 1 quart of kiwi juice per gallon. The amount of each kind of juice the company has on hand varies from day to day. How many gallons of each blend can it make on a day with the following stocks?

- 800 quarts of pineapple juice, 650 quarts of orange juice, 350 quarts of kiwi juice.
- 650 quarts of pineapple juice, 800 quarts of orange juice, 350 quarts of kiwi juice.
- A quarts of pineapple juice, B quarts of orange juice, C quarts of kiwi juice.

Investing in Municipal Bond Funds Exercises 55 and 56 are based on the following data on three tax-exempt municipal bond funds.¹⁸

	2003 Yield
PNF (Pimco NY)	6%
FDMMX (Fidelity Spartan Mass)	5%
FFLIX (Fidelity Spartan Florida)	7%

55. ● You invested a total of \$9000 in the three funds at the beginning of 2003, including an equal amount in FDMMX and FFLIX. Your 2003 yield for the year from the first two funds amounted to \$400. How much did you invest in each of the three funds?

56. ● You invested a total of \$6000 in the three funds at the beginning of 2003, including an equal amount in PNF and FDMMX. Your total yields for 2003 amounted to \$360. How much did you invest in each of the three funds?

¹⁸ Yields are rounded. SOURCES: www.pimcofunds.com, www.fidelity.com. January 18, 2004.

Investing in Stocks Exercises 57 and 58 are based on the following data on three computer stocks.¹⁹

	Price	Dividend Yield
APPL (Apple Computer)	\$25	0.6%
HPQ (Hewlett Packard)	25	1.2
DELL	35	0

57. You invested a total of \$5800 in Apple, Hewlett Packard, and Dell shares at the above prices, and expected to earn \$21 in annual dividends. If you purchased a total of 200 shares, how many shares of each stock did you purchase?

58. You invested a total of \$6750 in Apple, Hewlett Packard, and Dell shares at the above prices, and expected to earn \$45 in annual dividends. If you purchased a total of 250 shares, how many shares of each stock did you purchase?

59. ♦ **tech** **Ex Population Movement** In 2003, the population of the U.S., broken down by regions, was 53.3 million in the Northeast, 64.0 million in the Midwest, 101.6 million in the South, and 65.4 million in the West.²⁰ The matrix P below shows the population movement during the period 2003–2004. (Thus, 98.79% of the population in the Northeast stayed there, while 0.20% of the population in the Northeast moved to the Midwest, and so on.)

$$P = \begin{matrix} & \begin{matrix} \text{To} & \text{To} & \text{To} & \text{To} \\ \text{NE} & \text{MW} & \text{S} & \text{W} \end{matrix} \\ \begin{matrix} \text{From NE} \\ \text{From MW} \\ \text{From S} \\ \text{From W} \end{matrix} & \begin{bmatrix} 0.9879 & 0.0020 & 0.0081 & 0.0019 \\ 0.0014 & 0.9895 & 0.0063 & 0.0028 \\ 0.0027 & 0.0025 & 0.9927 & 0.0022 \\ 0.0010 & 0.0030 & 0.0050 & 0.9909 \end{bmatrix} \end{matrix}$$

Set up the 2003 population figures as a row vector. Assuming that these percentages also describe the population movements from 2002 to 2003, show how matrix inversion and multiplication allow you to compute the population in each region in 2002. (Round all answers to the nearest 0.1 million.)