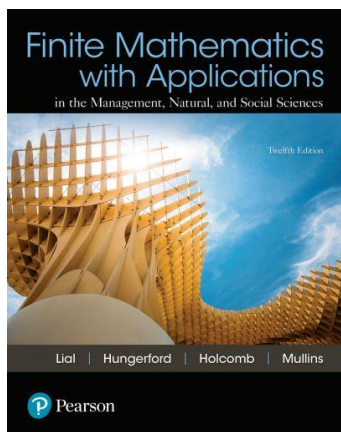## Finite Mathematics with Applications
in the Management, Natural, and Social Sciences
Twelfth Edition

Margaret Lial, *American River College*
Thomas Hungerford, *St. Louis University*
John Holcomb, *Cleveland State University*
Bernadette Mullins, *Birmingham Southern College*

Chapter-by-Chapter Changes

The authors incorporated a number of improvements to the 12th edition after careful consideration and extensive feedback from those who teach the course regularly. Here is a detailed list of the chapter-by-chapter changes that were made.

Major Reorganizations
- In Chapter 5, changed the notation for financial formulas to match the notation used in the TVM solver from the TI-84 calculator.
- In Section 10.2, added Weighted Averages to the section so that students can learn to calculate their own final grade when different components of a course count for different percentages.
- In Chapter 10, moved boxplots from Section 10.4 to Section 10.3 because boxplots are a tool to visualize variation and variation is discussed in Section 10.3.
- Material in the previous edition on using the normal distribution to approximate the binomial distribution in Section 10.5 was moved to Section 10.4 and consolidated. The normal approximation to the binomial is not as important a topic today as it once was as technology makes calculating exact binomial probabilities easy. However, the conceptual understanding of the ideas can be important for students to learn, so the material was condensed and put in the section on normal distribution.

Chapter 1
- In Section 1.1, updated six exercises to utilize the most recent Consumer Price Index data, six exercises to utilize recent percent change in stock prices of well-known companies, and four exercises to utilize the most recent data on disposable income.
- In Section 1.2, updated seven exercises to utilize the most recent data on net earnings for a well-known company and replaced six physical science exercises with exercises on profits for two well-known companies.
- In Section 1.3, reconfigured the solution to Example 7 to clarify why the sum of two perfect squares cannot be factored with real numbers. Also added titles to several definition boxes to clarify what is being described.
- In the exercise portions for Section 1.4, added reminders of how to calculate the area for circles, squares, and triangles. Also rewrote an exercise to clarify what is the average cost before asking to calculate it. Updated four exercises with more current data on prices for ads on the Super Bowl TV broadcast. Also updated four exercises utilizing the average cost per hour of employee health insurance.

- Updated Example and Checkpoint 10 of Section 1.5 to reflect current data on enrollment in higher education. Updated twelve exercises to reflect the current annual domestic revenue from the sale of movie tickets, Facebook revenue, and the number of part-time college/university students.
- Replaced Example 3 in Section 1.6 with a current function involving the total amount of money invested in IRA accounts. Updated Example and Checkpoint 12 with an example related to the number of subscribers to Apple Music and Spotify. Updated fourteen exercises to include recent data involving the federal debt, social security intakes, and the number of active users for Twitter and Instagram.
- In Section 1.7, updated Example and Checkpoint 5 to use a parabolic function to model Ford's revenue for recent years. Updated ten of the application exercises with functions modeled on data from National Transportation Institute and the U.S. Energy Administration.
- In the Review Exercises, updated twenty of the applied exercises with functions based on data stock prices, computer prices, government spending, oil output, vehicles sold, flight departures, and research spending by the U.S. government.

Chapter 2
- Added a new example in Section 2.1 with unemployment rate data to better illustrate determining the bounds on axes when graphing, and added four exercises that are similar on military spending and procurement as well as mining fatalities. Updated Example 6 to more recent data on the S&P 500. Updated graphs that students interpret in the exercises to include data on ATM fees; chicken, beef, and pork consumption; and the stock prices of Netflix and Apple.
- In Section 2.2, added a figure to give examples of lines with negative slope. Also added an alternate definition of perpendicular lines as non-vertical lines whose slopes are negative reciprocals of one another. Updated Example 8 to show this property as well as the fact that the slopes have product equal to -1. Updated two of the application examples and one of the Checkpoints to illustrate linear expressions for emerald prices and video streaming in China. Updated applications in the exercises with four related to light beer sales, four to global malaria cases, two for Olympic 5000 meter winning times, and four more exercises on luxury handbags, cocoa production, and employee and employer health care costs.
- Updated Examples 1-4 in Section 2.3 with current data on full-time faculty in colleges and universities. Updated Examples 5 and 6 with more recent data on the unemployment rate and enrollment in higher education. Updated or replaced fifteen of the application exercises with recent data on CPI, the number of tax returns filed, the number of employees working in education and leisure and hospitality, sales for Cisco Systems in China, South Korea's petrochemical exports, credit unions, student loans, Google ad revenue, street and highway construction, cable subscribers, software publishing, and life expectancy.
- In Section 2.4, replaced one science exercise with a current exercise based on recent polling data on workers' engagement. Updated two other exercises with current income tax rates.
- Updated seven of the application exercises in the Review Exercises section with new problems or new data on student loans, bunting in baseball, median household income, charitable giving, two and four-year college tuition, and cellular data plans.
- Case Study 2 was updated to include an example of Chipotle Mexican Grill, Inc. where extrapolation turned out not to make accurate predictions of net income due to E. coli and norovirus outbreaks. Also updated another example with revenue data from Twitter to show how a linear function might have high correlation, but the line under-predicts and over-predicts in a regular pattern. Updated the exercises in the Case Study with data on the stock price of Caterpillar and average hourly wages.

Chapter 3

- In Section 3.1, improved exposition of functional notation. Added three new examples and new parts added to two other examples to further illustrate the concepts of a function and representations from a graphical, numerical, algebraic, and verbal point of view. Added fourteen new exercises, including updated data on GDP, consumer consumption, stock prices, taxes, and inflation.
- In Section 3.2, added four new examples (and corresponding Checkpoint exercises) and a new part to one other example, including real-world data to illustrate piecewise defined functions for water bills and postal rates, and graphical examples involving crude oil and housing prices. In exercises, added twelve new exercises in real-world contexts such as Medicare, social security, CPI, smoking rates, shareholders' equity, iPhone sales.
- In Section 3.3, annotated surplus/shortage figure to combine verbal and visual illustration of a concept. Added one new example to illustrate linear depreciation and ten new exercises involving fixed costs, variable costs, revenue, break-even points, and others.
- In Section 3.4, added two new examples (one by hand and one using a graphing calculator) and a new part to one other example to illustrate quadratic models and the usefulness of the vertex of a parabola. Added seventeen new exercises, including real-world data on revenue for public companies, commodity pricing, and the federal debt.
- In Section 3.5, added two new examples that demonstrate that certain real-world data may be represented well by cubic or quartic models. Added eleven new exercises involving revenue, cost, and profit for public companies; consumer confidence; and social science examples.
- In Section 3.6, improved exposition or use of color to illustrate concepts in three examples.
- Added three new exercises involving average cost functions and biological modeling.
- In the Review Exercises, added fifteen new exercises spanning content throughout the chapter including applications in business, health sciences, and the social sciences such as cost, revenue, and profit for public companies, alcohol consumption, population growth (domestic and foreign), and student loans.
- Rewrote the Case Study involving revenue, cost, and profit. The examples and exercises within the case study illustrate that the quantity of a product that maximizes revenue is typically different from the quantity that maximizes profit.

Chapter 4

- In Section 4.1, updated application Examples 5 and 6 and Checkpoint 7 with data on wine consumption and assets of AIG. Replaced or update ten of the exercises with current data on the assets of Prudential Financial, Inc., Netflix costs, GDP for China and the U.S., asset management, imports from Vietnam, and subprime mortgages.
- Replaced Examples 1 and 2 in Section 4.2 with current data on debt in the U.S. and sales of single-family homes. Updated Example 4 with more recent data on infant mortality rates. Replaced Example 6 and Checkpoint 4 with a current example on the price of scrap steel.
- Replaced or updated eleven of the application exercises with data on wind power, oil production, office rent, personal consumption, Medicare expenditures, Chinese assets in banks, internet access in China, seat belt use, death rates, food assistance, and labor force participation.
- In Section 4.3, added a graph of several logarithmic functions of different bases to help student visualize logarithmic functions better. Replaced an application example with a current logarithmic model function on wind energy generated in the U.S. Updated or replaced eight of the application exercises with data on health insurance costs, dairy expenditures, credit union assets, border patrol budgets, opioid deaths, iPhone sales, and vehicle miles travelled.

- In Section 4.4, utilized color better to indicate non-possible solutions to logarithmic equations. Replaced Example and Checkpoint 7 with a new example on new jobs added to the U.S. economy. Also added a new example and checkpoint (using data on the digital grocery market) to illustrate solving for *x* with functions of the form $f(x) = ab^x$. Updated or replaced twelve of the application exercises with data on foreign earnings, nursing degrees, veterans' benefits, Snapchat users, wind energy, Japanese messaging, CVS Health earnings and revenue, the number of teachers in the U.S., Best Buy revenue, Twitter stock price, and outstanding loans in U.S. banks.
- In the Review Exercises, updated or replaced ten of the application exercises with current data on exports to Mexico, Royal Caribbean share price, the number of murders in Chicago, crude oil and coal futures, recent earthquakes, FedEx profits, Starbucks and Dunkin' Donuts App users, and bank capital.
- Updated Case Study examples and exercises with more recent data and graphs from gapminder.org.

Chapter 5
- In Section 5.1, more exposition regarding corporate bonds was added and Example 2 for a current Bank of America corporate bond was updated. Updated Examples 8 and 9, as well as Checkpoints 8 and 9, with current examples of treasury bills. Updated six exercises were updated with current bond rates, and eight exercises with current Treasury bill rates. Replaced ten application exercises with more realistic simple interest problems.
- Updated Figure 5.1 in Section 5.2 to better show how to use Microsoft Excel to create compound interest tables. Updated Examples 4, 8, and 10, as well as Checkpoint 3, with current interest rates for money market accounts. Updated Example 13 to reflect current inflation rates, and updated six of the exercises to reflect current money market rates.
- In Section 5.3, updated Example and Checkpoint 3, as well as Example 7, with current money market rate data. Updated six of the exercises to reflect current money market rates. Added eight exercises using historical savings rate to provide broader practice with these types of problems. Finally, updated six of the exercises to provide more realistic practice with the material.
- In Section 5.4, changed Example 1 to exposition to allow students to grasp the material before applying it in an example. Added an example and checkpoint to calculate the monthly payment on an auto loan. Updated the example on mortgage amortization to reflect current rates. Also added exposition on calculating the total amount of interest paid over the course of the loan. Added an example and checkpoint on the savings when making extra payments to the principal of a mortgage loan. Also updated the example and checkpoint on lottery winnings. Updated eight of the application exercises to include more recent auto and mortgage rates. Added two more exercises for practice calculating the savings when extra payments are added to the principal.
- In the Review Exercises, updated four of the exercises to reflect current student loan rates.
- Completely rewrote Case Study 5 to have students explore using the Rule of 72 (which yields a rough estimate of how long it takes for an invested amount of money invested to double in value). Wrote Examples and Exercises using historical rates of return for various investing scenarios.

Chapter 6
- In Section 6.1, added nine new exercises involving solving systems of two equations in real-world settings, including Google trends, workforce participation for men and women, cancer and heart disease deaths, and population changes for the millennials, Generation X, and boomers.
- In Section 6.2, added exposition that the reduced row echelon is unique whereas the row echelon form need not be unique. Added one new Technology Tip to help students use the graphing calculators to work with matrices.

- In Section 6.3, added nine new exercises involving solving systems of up to four equations in real-world settings including ride-sharing, currency conversion, and sports.
- In Section 6.4, improved explanation of properties of addition of matrices. Added four new exercises involving business and economics (credit card debt and earnings for college graduates) and health (organ transplants).
- In Section 6.5, improved explanation of properties of multiplication of matrices. Added five new exercises involving matrix multiplication including data from the Franchise Business Review on the investment needed to launch various new franchise locations.
- In Section 6.6, improved exposition of code theory and routing (see Examples 7-9). Added four new exercises, including contexts such payment processing services and truck rental.
- In Review Exercises, added five new exercises (several with multiple parts) in real-world settings, including stock prices and dividends.

Chapter 7
- Replaced Example 9 and Checkpoint 7 in Section 7.1 with an example using a realistic investing scenario. Updated four exercises with current data for realistic investing scenarios.
- In Section 7.2, renamed the two approaches to solving systems of equations with two unknowns to be the "Algebraic Method" and the "Calculator Method" to avoid confusion by using the term "Graphical Method" (from the previous editions) to specifically relate to graphing both equations on the same screen and using the intersection finder. Updated Example 3 to provide a better example where corner points are not all on the x or y axes.
- Updated Example 3 in Section 7.3 with current stock prices for a more up to date investing scenario. Changed Exercise 16 to reflect a more realistic nutrition situation and updated six exercises with recent mutual fund data for realistic investing scenarios.
- In Section 7.4, updated screenshots of Microsoft Excel to better show students and teachers how to use Excel for the simplex method.
- In Section 7.5, updated two of the exercises to more realistic scenarios.

Chapter 8
- In Section 8.1, made more prominent the definitions of proper subset. Updated Example 2 to better reflect scenarios when a set is a proper subset of another and when it is not, and updated the context to that of stock performance. Updated Example 9 with current stock performance for selected companies. Updated four applied exercises with current data on sales in the eating and drinking industries, eight exercises on current subscribes to cable services, and six exercises on farm product production comparing 2011 to 2016.
- In Section 8.2, updated Example 4 to reflect website viewing rather than magazine subscriptions. Updated Example and Checkpoint 7 with recent employment status data. Updated ten of the application exercises with data from the movie business, numbers of business partnerships, life classification, and job satisfaction.
- In Section 8.3, updated Example and Checkpoint 8 with current data from the General Social Survey on standard of living. Updated two exercises were updated with current data on fatal work injuries, two exercises based on data from the General Social Survey were updated, and added six new exercises based on S&P 500 stock data.
- In Section 8.4, updated application Examples 9 and 10 (as well as Checkpoints 8 and 9) with current data on traffic fatalities and S&P 500 stocks. Updated two additional exercises with current traffic fatality data, and two exercises with current data from the 2016 General Social Survey. Updated an additional twenty-one exercises with data on education and earnings tax revenue, S&P 500 data, and hours worked per week.

- In Section 8.5, replaced the motivating exposition and Example 1 with data on stock performance of the S&P 500. Updated Example 4 with current data on female-owned businesses. Updated Example 10 with current data on partnerships and corporations. Added four exercises related to firm size, six exercises on number of hours worked per week, and ten exercises were added on airline on-time data. Updated six exercises with current data on confidence in major corporations.
- Replaced Section 8.6 Example 1 with a new example focused on start-up success and its relationship to whether there is at least one female founder. Updated Example 2 to reflect data from the 2016 General Social Survey on marital status and number of children. Added two exercises on S&P 500 data. Updated four exercises on current earnings and education attainment data, four exercises with current vehicle sales data, six exercises on stock performance on the NYSE and NASDAQ exchanges, and six exercises on happiness.
- Updated four Review Exercises with current data on movie classifications, six exercises on sector classifications for stocks in a mutual fund, twelve exercises involving education attainment and confidence in corporations, and four exercises on stock exchange performance.
- In Case Study 8, added an exercise to calculate the probability a woman who tests positive for breast cancer with a mammogram actually has cancer.

Chapter 9
- In Section 9.1, updated the motivating exposition, Example 2, and Example 7 with current data from the 2016 General Social Survey. Updated Examples 3 and 6 with more realistic scenarios. Updated two exercises with current data on auto sales and gaming devices, and two exercises on expected payouts for the Wimbledon tennis championships.
- In Section 9.2, updated Example 2 with current data from the Home Depot website and added an accompanying Checkpoint. Updated Example 9 to reflect the number of Republican aspirants at the 2016 Iowa Caucus. Updated Example 16 to reflect the current way to play Powerball.
- In Section 9.3, updated one of the exercises updated to reflect current membership of the House Financial Services Committee.
- In Section 9.4, changed the motiving exposition to focus advancing stocks on the NYSE. Updated Example 1 and Checkpoint 2 with recent data on job satisfaction. Updated and consolidated Examples 3–5 and Checkpoints 4 and 5 with applications of student loan defaults and new business failures. Updated the spreadsheet technology tip to better help students use Excel. Replaced twelve exercises with new ones focused on student loan debt. Updated four exercises on education needed for work, six exercises on stock ownership, and four exercises on new vehicle sales.
- In Section 9.5, replaced Example 1 with a new example on wireless customer churn. Updated Example 6 with current data on vehicle sales. Replaced two of the exercises with more realistic scenarios and one with current vehicle sales data.
- In the Review Exercises, updated nine exercises on vehicles per household and house size, smartwatches, stock performance, internet access, smartphone ownership, bank earnings, and household earnings.

Chapter 10
- In Section 10.1, updated Examples 1–3 and Checkpoints 2 and 3 with current tuition data. Updated twenty-six of the application exercises using data on stock price, dividend yield, market capitalization, household income, utility bills, rent payments, heights, high school graduation rates, degree attainment, student loan defaults, cat ownership, personal bankruptcies, and chicken production.

- In Section 10.2, replaced Example 1 with revenue from Apple Corporation. Updated Example 3 with current tuition data. Added exposition on how to find the median for grouped data. Also added exposition, an example, and a checkpoint on weighted averages, the applications of which include calculating a final grade when different components count for different percentages. Added seventeen exercises on topics of dog and cat ownership, team payrolls and values, movies, SiriusXM, Dr. Pepper and Snapple revenue, market capitalization, household income, degree attainment, final averages, and final exam scores.
- In Section 10.3, moved exposition, examples, and checkpoints on boxplots that were previously in Section 10.4 to 10.3 and updated appropriately. Also, updated the notation in formulas to better convey how to use them. Updated Example 4 with current tuition data. Updated six exercises on state expenditures, two exercises on stocks data, six exercises on movie studio data, six exercises on boxplots for IBM and Microsoft data and eight boxplot exercises on state expenditure data.
- In Section 10.4, revised all renderings of the normal probability density curve to better reflect the shape of the normal curve. Moved and condensed material on the normal approximation to the binomial previously in Section 10.5 to Section 10.4. Added four exercises on heights of adults, and twelve exercises on normal approximation to the binomial in the context of job satisfaction and student debt.
- Changed the topic of the first ten exercises of the Review Exercises to involve stock data. Added or updated two exercises involving Macy's and Kohl's revenue, four exercises on upper arm circumference, six involving new vehicle sales, and eight exercises on higher education and living at home.
- Updated examples and exercises in Case Study 10 with current data on how to calculate risk estimates with the standard deviation for stocks or mutual funds.