Detailed Learning Objectives for Required Math Course for Undergraduate Business Students at U of Colorado Boulder

Mathematical Analysis in Business, MATH 1112

MATH 1112 is a hands-on problem-solving course, using problems with mathematical foundations from real business contexts. Students use Excel to work with substantial data sets.

We changed to this requirement from a more-standard Finite Math + Business Calculus (MATH 1071+1081) requirement in 2015, after a pilot run of the new course in AY1415. As of 2019, about 1600 students take it each year.

Motivation behind the change:

- Give students practice with the truly hard parts of math they will encounter in their professional lives: recognizing which math skills are relevant and applying them outside the bounds of a textbook chapter.
- Teach tangible problem solving skills, using Excel as a computational platform.

Course Learning Objectives

0. Determine the mathematical operations needed to guide decisions in business contexts.

1. Recognize situations in which unit conversions are useful and apply the conversions.

Sample applications:

Skill	Mod #	Mod Name
Convert currencies using foreign exchange rates.	1	Foreign Exchange
Determine number of whole shares of a stock that can be purchased with an amount of money for a given stock price.	2	Stock Prices
Make adjustments in stock prices to account for dividends and stock splits.	2	Stock Prices
Convert between kilobytes, megabytes, and gigabytes.	5	Cell Phone Plans
Find total ingredient usage for an order of different quantities and types of sandwiches.	10	Sandwich Shop

Detailed objectives:

1.1 Calculate the conversion factor and then apply it.
1.2 Apply multiple conversions.
1.3 Apply systematic sets of conversions using matrix multiplication.
1.4 Apply adjustments to conversions to account for whole number constraints.

2. Understand and describe how a quantity is changing over time.

Sample applications:

Skill	Mod #	Mod Name
Graphically show the time trend of a currency exchange rate and identify the dates with the strongest and weakest positions relative to another currency.	1	Foreign Exchange
Graphically show the actual vs. projected time trend of stock prices.	2	Stocks
For two dates, calculate the percentage change in a stock price and the Compound Annual Growth Rate (CAGR). Interpret those calculations.	2	Stocks
Calculate forecasts of costs, revenues, and net income; build graphs to show trends; interpret the graphs.	11	Sales Forecasting

Detailed objectives:

2.1 Calculate and interpret positive and negative percentage change.
2.2 Calculate and interpret annualized percentage change.
2.3 Calculate and interpret positive and negative absolute change.
2.4 Extrapolate linear and geometric trends.

3. Understand and describe how two quantities change in tandem.

Sample applications:

Skill	Mod #	Mod Name
Use a scatter plot and the correlation coefficient to analyze the relationship between two currency exchange rates.	1	Foreign Exchange
Use a scatter plot and the correlation coefficient to analyze the relationship between price and quantity.	6	OJ
Investigate which questions on a survey have correlated responses.	7	Caffeinated Products
Perform sensitivity analysis in a spreadsheet model: understand and communicate how the inputs affect the outputs.	4, 11	Taxes, Sales Forecasting

Detailed objectives:

3.1 Calculate and interpret correlation coefficients.
3.2 Understand and communicate how model inputs affect model outputs.

4. **Find values that solve an equation or system of equations or that optimize an expression. Use graphical, numeric, and symbolic approaches to find the answers.**

Sample applications:

Skill	Mod #	Mod Name
Solve for the exchange rate that yields a given margin.	1	Foreign Exchange
Find the income at which taxes owed are equal under two tax plans.	4	Taxes
Find the equation of a line that best fits a cloud of points.	6	OJ
Find the quantity at which two production technologies have equal costs.	8	Kickstarter
Find the price that optimizes profit for a given estimated demand curve.	6, 8	OJ, Kickstarter
Calculate forecasting error.	9	Forecasting Revisited

Detailed objectives:

4.1 Recognize, write, and solve linear equations and systems of linear equations.
4.2 Solve equations of one variable.
4.3 Check solutions using multiple methods: numeric, symbolic, and graphical.
4.4 Find optimal values in various settings with discrete data.
4.5 Understand total squared difference as a measure of fit and find values that minimize it.

5. **Understand and use mathematical notation. Be able to translate a symbolic expression to a spreadsheet model. Make the connections between symbolic expressions and graphs.**

Sample applications:

Skill	Mod #	Mod Name
Identify the inputs and implement the expression for CAGR.	2	Stocks
Write piecewise linear functions to represent taxes owed under the U.S. personal income tax code.	4	Taxes
Interpret graphs of cell phone plan costs as a function of usage.	5	Cell Phone Plans
Use summation notation to represent total costs, revenues, or units over multiple periods.	11	Sales forecasts

Detailed objectives:

5.1 Write and interpret functional notation, including piecewise definitions.
5.2 Write expressions that model linear relationships.
5.3 Write expressions that model aggregation, including summation notation (sigma including an index).
5.4 Write expressions that model linear and geometric growth.
5.5 Translate verbal descriptions into mathematical expressions.
5.6 Interpret relationships presented graphically.

6. Select metrics to summarize data, calculate those metrics, and interpret them.

Sample applications:

Skill	Mod #	Mod Name
Find averages and weighted averages of survey responses or campaign performance metrics.	7, 8	Caffeinated Products, Kickstarter
In survey response data, determine whether an average of responses has a clear interpretation.	7	Caffeinated Products
Build graphs to show the distribution of survey responses.	7	Caffeinated Products
Combine logical rules with averaging to find the average funds raised over a set of crowdsourcing projects.	8	Kickstarter
Calculate moving averages of ingredient usage to place orders to cover anticipated demand.	10	Sandwich Shop

Detailed objectives:

6.1 Find absolute frequencies (tallies or counts of observations that meet certain criteria).
6.2 Find relative frequencies (percentages from criteria-based tallies).
6.3 Convey data summaries by designing graphs and tables.
6.4 Calculate averages and weighted averages.
6.5 Calculate rolling (moving) totals and averages.
6.6 Interpret binary indicator variables (e.g., data flagged as 1 and 0) and their averages.

7. Use probabilities to express uncertainty about events.

Sample applications:

Skill	Mod #	Mod Name
Identify consistent and inconsistent sets of probability assessments.	3, 9	Forecasting
Evaluate expected values for a reference metric for a set of scenarios with assigned probabilities.	8	Kickstarter

Detailed objectives:

7.1 Check for consistency of a set probability assessments.
7.2 Derive total probabilities from verbal descriptions of situations.
7.3 Calculate expected values and understand and interpret their meaning.

8. Use Excel efficiently to navigate, explore, analyze, and visualize large data sets.

Sample applications:

Skill	Mod #	Mod Name
Perform analyses on twenty years of daily stock price data.	2	Stocks
Analyze survey data.	7	Caffeinated Products
Compare success rates of subgroups of a database of thousands of crowdfunding projects.	8	Kickstarter
Identify time patterns in retail transaction data.	10	Sandwich Shop

Detailed objectives:

8.1 Use cell references in formulas.
8.2 Write formulas that can be dragged and copied.
8.3 Integrate data sources using lookup functions.
8.4 Use logical statements within functions.
8.5 Use the "what-if" capabilities in Excel.
8.6 Select, create, and annotate graphs.

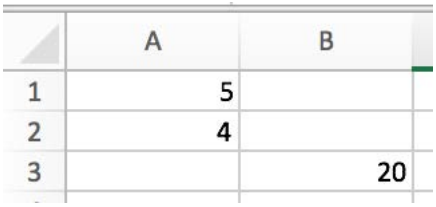
Module 0 (Intro) Learning Outcomes:

Mathematical Skills:

- ☐ Translate verbal descriptions into equivalent mathematical expressions. (5)
- ☐ Write expressions that represent percentage reductions. (2,5)
- ☐ Relate tabular data and graphical data. (5)

Excel Skills:

- ☐ Use the "=" symbol and other operators (+,-,*,/) to perform basic calculations.
- ☐ Reference input cells to perform calculations. For example, the equation in cell B3 to calculate 5*4 would be "=A1*A2" (cell-referencing) as opposed to "=5*4" (hard-coding).



	A	B
1	5	
2	4	
3		20

- ☐ Understand relative and absolute cell references (proper use of the $ sign): for every row and column reference, know whether the $ must be used, must be omitted, or can either be used or omitted.

Applications

- ☐ Write expressions for revenue and profit given verbal explanations of what they represent.
- ☐ Efficiently calculate revenue and profit based on demand projections at different price points.

Module 1 (Foreign Exchange) Learning Outcomes:

Mathematical Skills:

- ☐ Convert units using conversion ratios. (1)
- ☐ Calculate percent change (increase or decrease) and interpret its meaning. (2)
- ☐ Calculate the correlation coefficient and interpret its value. (3)
- ☐ Interpret time trend (line) charts and scatter plots. (2, 5)
- ☐ Translate verbal descriptions into equivalent mathematical expressions. (5)
- ☐ Solve an equation of a single variable. Solve symbolically and confirm solution numerically and graphically. (4)

Excel Skills:

- ☐ Continue to use relative and absolute cell references (proper use of the $ sign).
- ☐ Be able to predict how a formula will change when dragged or copied to another cell.
- ☐ Be able to freeze panes and resize columns.
- ☐ Recognize what ##### in a cell means.
- ☐ Use the CORREL() function to find the correlation coefficient between two variables.
- ☐ Use the SUM() function to add a list of numbers.
- ☐ Generate various graphs in Excel (scatter, line, etc.).
- ☐ Begin to learn common keyboard shortcuts:

    - Command+shift+down to highlight (use Ctrl instead of Command on Windows).
    - Command+c to copy, Command+v to paste (Ctrl+c, Ctrl+v on Windows).
    - Hold Command to keep something highlighted.
- ☐ Change cell formats (percent, decimal value, display settings, color, etc.) as appropriate, but recognize that the underlying value does not change when the format changes.

Applications

- ☐ Map increases and decreases in exchange rates to the idea of stronger and weaker currencies.
- ☐ Analyze trends in currencies graphically: trends over time and co-movement between two exchange rates.
- ☐ Use bid and ask rates appropriately to calculate value of currencies exchanged.
- ☐ Calculate profit margin with revenue and costs in two different currencies.
- ☐ Find an exchange rate that yields a specified profit margin.

Module 2 (Stocks) Learning Outcomes:

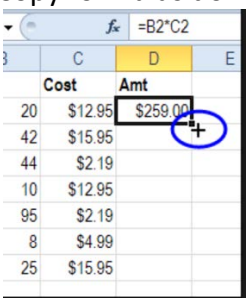
Mathematical Skills:

- ☐ Write expressions that correctly use the order of operations (PEMDAS). (5)
- ☐ Understand when rounding down is appropriate. (1)
- ☐ Understand the difference between absolute and percent gain (growth) and loss and calculate these values. (2)
- ☐ Apply growth rates in one quantity (e.g., Adjusted Close Price) to another quantity (e.g., initial investment value). (2)
- ☐ Calculate, interpret, and apply ratios (e.g., Adjusted Close Price to Close Price). (1)
- ☐ Understand how combinations of percentage gains and losses adjust prices (e.g., up 10%, down 10%). (2)
- ☐ Solve an equation of a single variable. Solve symbolically and confirm solution numerically and graphically. (4)
- ☐ Calculate and interpret Compound Annual Growth Rate (CAGR). (2)
- ☐ Perform geometric extrapolations. (2)

Excel Skills:

- ☐ Continue to use relative and absolute cell references (proper use of the $ sign).
- ☐ Use VLOOKUP() to find a value from an array given a unique identifier. (Advanced but more flexible version for look-ups: composition of INDEX() and MATCH()).
- ☐ Use FLOOR(), ROUNDDOWN() or similar function to round a value down.
- ☐ Use MAX() and MIN() to find the largest or smallest value in a set.
- ☐ Use logical formulas like IF().
- ☐ Use COUNTIF()/COUNTIFS() to count data given certain criteria.
- ☐ Use COUNT() to count cells containing a number (COUNTA() to include alphanumeric values).
- ☐ Change format of displayed values (e.g., dates displayed as numbers to short date).
- ☐ Graph data and add a trend line as appropriate.

- Continue to use common keyboard shortcuts:
  - Command+shift+down to highlight
  - Command+c to copy, Command+v to paste
  - Hold command to keep something highlighted
  - Copy formulas down to fill a column (use plus sign and double click)



- Begin to understand the meaning of various Excel errors (####, #NA, #VALUE, #DIV/0, etc.)
- Use parentheses in equations to ensure proper order of operations in Excel (PEMDAS).
- Begin to be able to structure Excel spreadsheets in an organized manner.
- Graph multiple series on one chart.

Applications:

- Perform calculations on stock prie data (open, close, daily range, daily change, etc.)
- Analyze graphs of stock prices over time.
- Understand the difference between adjusted close and close prices.
- Calculate value of stock using percent growth based on adjusted close values.
- Determine the value of an investment given an initial dollar investment or number of shares purchased.
- Find the value of an investment on a specified date given a purchase date.
- Understand and apply the concept of Dollar-Cost Averaging.
- Project future prices using historical CAGR.

Module 3 (Forecasting) Learning Outcomes:

Mathematical Skills:

- Understand probabilities as forecasts about binary events. (7)
- Understand what it means for a probability to be logically consistent. (7)
- Calculate percent change (growth/loss). (2)

Excel Skills:

- No new Excel skills introduced in this module.

Applications:

- Identify and collect useful data to make informed forecasts for stock prices, local and global events, weather, etc.
- Confirm that set of related probabilities are logically consistent.

Module 4 (Taxes) Learning Outcomes:

Mathematical Skills:

- ☐ Write simple (two-part) piecewise linear functions. (5)
- ☐ Identify patterns to extend a simple (two-part) piecewise linear function to more complex setting (five or more parts). (5)
- ☐ Interpret the slope, the kinks, and the asymptote in piecewise linear functions, both in functional notation and in a graph. (5)
- ☐ Interpret the key features in graphs (kinks, asymptotes) of non-linear functions, beyond piecewise linear. (5)
- ☐ Find and interpret the intersection point(s) of non-linear functions, both graphically and numerically. (4)

Excel Skills:

- ☐ Structure Excel spreadsheets in an organized manner.
- ☐ Write formulas that reference cells instead of hard-coding values.
- ☐ Use previously introduced logical functions such as IF(), MAX(), and MIN().
- ☐ Explore the use of more sophisticated logical expressions with AND() and OR().
- ☐ Write draggable functions that allow you to easily extend a pattern of calculations.
- ☐ Use the Data Table tool to explore the relationship between model inputs and outputs.
- ☐ Create line graphs.
- ☐ Refine graphs by using settings for the labels, axes, data series, etc.
- ☐ Use the Goal Seek tool to find a target value of a calculated cell.
- ☐ Use the Goal Seek tool to find points of intersection of two functions.

Applications:

- ☐ Calculate taxable income from total income and other appropriate inputs,
- ☐ Calculate tax owed and percentage of income paid in taxes for a simple bracketed tax code.
- ☐ Calculate tax owed and percentage of income paid in taxes for a realistically complicated tax code.
- ☐ Interpret the relationship between total income and percentage of income paid in taxes.

Module 5 (Cell Phone Plans) Learning Outcomes:

Mathematical Skills:

- ☐ Perform unit conversions (Giga, Mega, Kilo). (1)
- ☐ Write simple (two-part or three-part) piecewise linear functions. (5)
- ☐ Write expressions that represent fixed and percentage reductions. (5)
- ☐ Decompose a model with many parts into set of sub-models and then pull together the parts to find the overall value. (5)
- ☐ Interpret the slope, the kinks, and the asymptote in piecewise linear functions, both in functional notation and in a graph. (5)
- ☐ Find and interpret the intersection point(s) of non-linear functions, both graphically and numerically. (4)

Excel Skills:

- ☐ Build a spreadsheet independently, with no starter sheet provided.
- ☐ Structure Excel spreadsheets in an organized manner, amenable to changes in input values and extension of models.
- ☐ Copy and rename sheets in Excel.

Applications:

- ☐ Calculate cell phone plan costs for different levels of usage of texts, minutes, and data.
- ☐ Compare plan costs under different levels of usage, and find usage levels that make two plans have the same overall cost.

Module 6 (OJ) Learning Outcomes:

Mathematical Skills:

- ☐ Write the equation of a line for a given slope and intercept. (5)
- ☐ Find the equation of a line using two points. (4, 5)
- ☐ Interpret a linear equation. (5)
- ☐ Interpret the correlation between two variables (e.g., price and quantity). (3)
- ☐ Graph scatterplots and trend lines and understand what they represent. (2, 3, 5)
- ☐ Understand the difference between estimated and actual values and calculate them as needed. (4)
- ☐ Calculate the sum of squared differences and understand what it represents. (4)
- ☐ Fit a line that minimizes the sum of squared differences on given data. (4)
- ☐ Understand what a best-fit line represents. (4)
- ☐ Understand the concept of an optimal value as a value that minimizes or maximizes an expression. (4)
- ☐ Numerically estimate an optimal value of a quadratic function. (4)

Excel Skills:

- ☐ Manipulate filters to display desired information.
- ☐ Understand the purpose and use of the SUBTOTAL() function, but no need to code it.
- ☐ Add data series to existing graphs.
- ☐ Add trendlines to graphs.
- ☐ Add in and use “Solver.”
- ☐ Use Excel to find the equation of a best-fit line (LINEST() or SLOPE() and INTERCEPT()) for a set of points.

Applications:

- ☐ Calculate actual revenue, estimated revenue, actual profit, estimated profit.
- ☐ Use price and quantity data to estimate a demand curve.
- ☐ Use a demand curve and a per-unit cost to find a profit-maximizing price.

Module 7 (Caffeinated Products) Learning Outcomes:

Mathematical Skills:

- ☐ Write expressions that correctly use the order of operations (PEMDAS). (5)

- ☐ Differentiate between relevant and extraneous data. (0)
- ☐ Understand, calculate, and interpret weighted sums and averages. (6)
- ☐ Understand and calculate averages based on subsets of data (e.g., by gender). (6)
- ☐ Scale data as appropriate (e.g., assigning probabilities to purchase intent responses or numeric values to ordinal frequency responses). (1, 6)
- ☐ Understand the conditions needed for equivalence between two sets of scaling factors. (6)
- ☐ Create and understand how to use frequency tables. (6)
- ☐ Use averages and (cumulative) percentages as performance metrics. (6)

Excel Skills:

- ☐ Freeze panes, color code, and resize columns in ways that enhance usability of the spreadsheet.
- ☐ Use keyboard shortcuts to select, fill, copy, paste items as needed.
- ☐ Use relative and absolute cell references (proper use of the $ sign).
- ☐ Use parentheses in equations to ensure proper order of operations (PEMDAS).
- ☐ Use AVERAGE() to calculate the average of a set of data.
- ☐ Use AVERAGEIF()/AVERAGEIFS() to calculate the average of values that meet specified criteria.
- ☐ Use COUNTIF()/COUNTIFS() to count data given certain criteria.
- ☐ Structure Excel spreadsheets in an organized manner.
- ☐ Transpose data or tables to facilitate dragging of formulas.
- ☐ Use SUMPRODUCT() to multiply the arrays together and return the sum of the products.
- ☐ Generate various graphs (column charts, scatter plots, etc.) and manipulate their elements (labels, ranges of axes, etc.).
- ☐ Understand the meaning of various Excel errors (####, #NA, #VALUE, etc.) and able to debug code if necessary.
- ☐ Anticipate tables/calculators that may be needed given a sample question that may be asked.
- ☐ Understand how to create new columns to “flag” items in a data set.
- ☐ Write logical statements using IF().
- ☐ Nest logical statements, e.g., IF(), OR(), AND() within IF().
- ☐ Able to seek out new functions to use that may not have been explicitly discussed in class.

Applications:

- ☐ Understand and analyze survey data.
- ☐ Calculate estimates of purchase intent, frequency, and uniqueness to compare appeal of multiple concepts.
- ☐ Understand what a top-two boxes score is and what it represents.
- ☐ Understand why we consider removing “don’t know” from calculations (normalizing distributions to exclude responses) and how to do that.

Module 8 (Kickstarter) Learning Outcomes:

Mathematical Skills:

- ☐ Understand what it means to use a 0/1 indicator to describe "success" and interpret the average value of a 0/1 indicator as a percentage of successful outcomes. (6)
- ☐ Calculate weighted averages. (6)
- ☐ Write linear expressions and interpret the slope and intercept. (5)
- ☐ Solve for the intersection of two lines. (4)
- ☐ Represent the intersection of two lines graphically. (4)
- ☐ Use multiple solution approaches—equations, graphs, numerical values—to check for correctness. (4)
- ☐ Numerically find an optimal value (e.g., price) given data to calculate an objective function (e.g., profit). (4)
- ☐ Derive total probabilities from verbal descriptions of situations. (7)
- ☐ Apply (scenario) probabilities to find probability-weighted averages (aka expected values). (7)

Excel Skills:

- ☐ Use previously learned functions (COUNTIFS(), AVERAGEIFS(), VLOOKUP() etc.) as needed.
- ☐ Seek out new functions to use that may not have been explicitly discussed in class as needed and apply previously learned Excel skills to new problems.
- ☐ Use SUMIF()/SUMIFS() to calculate the sum of an array given specific criteria.
- ☐ May use YEAR() function to extract the year from a date string.
- ☐ Remove duplicates from a set of data.
- ☐ Create drop downs using Data Validation to help with speed and accuracy of data entry.
- ☐ Use the Data Table tool.
- ☐ Create graphs.

Applications:

- ☐ Work with a large crowdfunding data set to calculate performance metrics (e.g., probability of success, amount raised) based on different criteria (e.g., year, project type, funding goal).
- ☐ Use data on comparable projects to estimate an amount raised per backer.
- ☐ Find the required number of backers of a project to reach a funding goal, given an estimate of amount raised per backer.
- ☐ Write expressions for total costs that have both a fixed component and a variable component (based on quantity).
- ☐ Find the breakeven quantity of two production options.
- ☐ Find an optimal price to charge based on survey data and cost estimates.
- ☐ Use scenario analysis with a model (baseline, pessimistic, and optimistic scenarios) to account for uncertainty.

Module 9 (Forecasting Revisited) Learning Outcomes:

Mathematical Skills:

- ☐ Calculate percent change (growth/loss). (2)
- ☐ Ensure logical consistency of a set of probabilities. (7)
- ☐ Interpret binary indicator variables (0/1) to represent outcomes of uncertain events. (6)
- ☐ Use and understand total squared difference as a measure of fit. (4)
- ☐ Tally observations that meet criteria (e.g., a value falls in a range and/or an associated variable has a certain value). (6)

Excel Skills:

- ☐ Create and refine histograms and column charts.
- ☐ Organize a spreadsheet and use relative and absolute references so that a series of related calculations can be accomplished by dragging the formula.

Applications:

- ☐ Calculate and understand total squared difference as a measure of forecasting accuracy.
- ☐ Identify the best forecasters in the group.

Module 10 (Sandwich Shop) Learning Outcomes:

Mathematical Skills:

- ☐ Understand the difference and how to find absolute frequency (counts) and relative frequency (percentages) and be able to calculate them both. (6)
- ☐ Translate assortment quantities into component quantities. (1)
- ☐ Understand and perform matrix multiplication 6. (1)
- ☐ Understand and calculate rolling totals. (6)
- ☐ Understand and calculate rolling (moving) averages. (6)

Excel Skills:

- ☐ Use MMULT() to multiply two matrices.
- ☐ Create and use Pivot Tables to display data in a useful way.
- ☐ Adjust options in Pivot Tables to change how information displays.
- ☐ Graph for absolute and relative frequency.
- ☐ Graph line/trend charts with multiple data series, including observed data plus moving averages.

Applications:

- ☐ Efficiently summarize product sales and ingredient data by time period, product type, and product.
- ☐ Use historical orders to forecast anticipated future quantities.
- ☐ Determine ingredient order requirements based on current inventory levels and stock on hand.