

MATHEMATICS FOR ECONOMISTS

IE University

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Semester: 1^o

Category: BASIC

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PREREQUISITES

Essential elements of algebra (pre-calculus), including operations with powers (negative and fractional powers) and fractions. Factorization, solving basic equations, working with inequalities and absolute values. We also recommend knowing the elementary functions (polynomial, rational, power, exponential, and logarithmic). The use of basic functionalities of MS-EXCEL® is also a must.

SUBJECT DESCRIPTION

People often think of Mathematics as a collection of different axioms and theorems, which build a complete theoretical system but have few connections (or no connections at all) with real-life problems. Fortunately, this conception of Mathematics, or at least of what we could call “applied mathematics in social sciences,” has changed over the last decades. From this new point of view, one must think of Mathematics not as a subject but as a collection of tools needed in any rigorous and complete analysis of complex problems in different contexts such as the economy, business, society, or public policies.

We live the birth of the fourth industrial revolution in light of some extraordinary technological advances. Simultaneous to this significant upheaval is an arrangement of financial, geopolitical, and demographic drivers of progress, each interacting in multiple directions and intensifying one another. This challenging scenario opens new opportunities for those professionals capable of managing and analyzing such complex situations.

A recently published report from the World Economic Forum states that solving complex problems will be the most valuable skill in coming years. A lack of proficiency in mathematics is the primary limitation to improving the power of abstraction, which is a crucial requirement for complex problem-solving. Students following this course will learn valuable tools to analyze economic and management problems.

OBJECTIVES AND SKILLS

The objective of this course is to provide the student with the quantitative tools required to analyze economic, business, or political problems. At the end of the term, students will take a good knowledge of relevant tools and methods. They will be able to know when and how to use them. We will guide the students through a new approach to Math learning with an entirely practical approach. We aim to engage both poets and quants.

Why should you learn Math? Math is critical to:

- Address economic problems through abstract models.
- State and solve formal models.
- Use the tools required to analyze economic and business issues.

What are the key learnings of this course?

- Discover the multiple applications of matrix algebra to real-life applications.
 - Economic analysis, cryptography, 3D graph animation.
- Know when and how to use a specific function to model some social and business phenomena.
 - For example, logarithms are essential to model growth, innovation adoption, or even pandemics.
- Use derivatives for finding critical information for decision-making.
 - Elasticities, MRS, maximizing revenues and profit or minimizing costs.
- Connect math tools with economic policy or management decisions.
 - Marginal products of labor and capital.
- Use Math in real-life scenarios by adding constraints to any problem.
 - How to deal with budget constraints or scheduling workers.
- Perform a dynamic analysis by using integration and differential equations.
 - Consumer and producer surplus.
- Interpret everything. Math is a language.
 - You must be able to translate a real-life problem into Math and interpret the results.

How are you going to learn about the above issues?

- Algebra is tedious but necessary. First, you need to understand the essentials.
- Do not worry; I am aware we live in the 21st century. You will use computers for many things in this course.
- Playing is an excellent approach to learning. You will work in teams and participate in solving some cases.

METHODOLOGY

We will use a blend of learning methodologies, including Peer Instruction, Flipped Classroom, and Case method, minimizing the classical lecture-based teaching.

Peer instruction is a methodology developed by Prof. Erik Mazur (Harvard University). This methodology involves students in their learning during lectures focusing their attention on underlying concepts. At the beginning of each face-to-face session, students will take a Quiz twice. The first time, individually, and the second, after a brief discussion within a small group of classmates. After most of the F2F sessions, students must work on some exercises that will be available online (on Blackboard IE CAMPUS).

The case method is widely used in Business Schools. It is a teaching approach that utilizes decision-forcing cases to put students in the role of people who faced difficult decisions at some point in the past. We will use the Case method in Sessions #4 and #26.

Teaching methodology	Weighting	Estimated time a student should dedicate to prepare for and participate in
Lectures	20.0 %	30 hours
Discussions	3.33 %	5 hours
Exercises	23.33 %	35 hours
Group work	26.67 %	40 hours

Other individual studying	26.67 %	40 hours
TOTAL	100.0 %	150 hours

PROGRAM

PART I. STATIC ANALYSIS

Static (or equilibrium) analysis is the starting point of Economic Analysis. From Mathematics, the static analysis comprises the fundamentals of Matrix Algebra. This part, which contains 11 sessions, will also study the most fundamental aspects of mathematical methods.

SESSION 1 (LIVE IN-PERSON)

Introduction to Applied Business Mathematics

Matrix Algebra. Basic matrix operations.

Learning goals:

- Use the notation and terminology of matrix algebra.
- Find the transpose of a matrix.
- Add and subtract matrices.
- Multiply matrices by a scalar.
- Multiply matrices together.
- Represent a system of linear equations in matrix notation.

MS-Excel: Basic matrix operations

Book Chapters: Mathematics for Economics and Business. Section 7.1 (See Bibliography)

Video: Session 1: Matrix operations (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 1" list of exercises (Available on IE Campus).

SESSION 2 (LIVE IN-PERSON)

Determinants. Matrix inversion.

At the end of this session, you should be able to:

- Understand the matrix equations involving the inverse matrix.
- Write down any identity matrix.
- Calculate the determinant of any square matrix (EXCEL).
- Detect whether a matrix is singular or non-singular (EXCEL).
- Find the inverse of any non-singular matrix (EXCEL).
- Use matrix inverses to solve systems of linear equations (EXCEL).

Book Chapters: Mathematics for Economics and Business. Section 7.2. Matrix Inversion. (See Bibliography)

Video: Session 2: Matrix inversion (Available on IE Campus)

Video: How to find an inverse matrix by using EXCEL (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 2" list of exercises (Available on IE Campus).

SESSION 3 (LIVE IN-PERSON)

Systems of Linear Equations. Cramer's rule.

Learning goals:

- Understand the limitations of using inverses to solve Systems of Linear Equations (SLE)
- Use the Cramer's rule to solve SLE.
- Apply Cramer's rule to solve some economic problems.

Book Chapters: Mathematics for Economics and Business. Section 7.3. Cramer's rule. (See Bibliography)

Video: Session 3: Cramer's Rule (Available on IE Campus)

Video: How to use EXCEL for solving Systems of Linear Equations (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 3" list of exercises (Available on IE Campus).

SESSION 4 (LIVE IN-PERSON)

Group Activity: In this session, you will work in groups to discover some of the fantastic applications of matrices to real-life problems. The groups will compete to solve the case, and their results will determine the grade obtained by each team member.

Practical Case: A Mysterious Message for Natalie: A Case for discovering the power of Math (QME010106-U-ENG-WOD-BC)

Prior to the session activity:

- Review contents and exercises corresponding to the previous sessions to be ready to contribute to the group activity.

SESSION 5 (LIVE IN-PERSON)

Graphs of linear equations

At the end of this session, you should be able to:

- Sketch a line by finding the coordinates of two points of the line.
- Sketch a line by using its slope and intercept.
- Use EXCEL for plotting linear functions and solve simultaneous linear equations graphically.

Book Chapters: Mathematics for Economics and Business. Section 1.3. (See Bibliography)

Video: Session 5 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 5" list of exercises (Available on IE Campus).

SESSION 6 (LIVE IN-PERSON)

Demand and Supply analysis: Market equilibrium.

At the end of this session, you should be able to:

- Use the function notation.
- Identify endogenous and exogenous variables in an economic model.
- Identify and sketch linear demand, and supply functions.
- Determine the market equilibrium (i.e.: price and quantity).

Use MS-Excel to represent market equilibrium conditions.

Book Chapters: Mathematics for Economics and Business. Section 1.5. (See Bibliography)

Video: Session 6 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 6" list of exercises (Available on IE Campus).

SESSION 7 (LIVE IN-PERSON)

Non-linear Equations.

Learning goals:

- Solve quadratic equations.
- Sketch the graph of a quadratic function.
- Solve quadratic inequalities.
- Determine the market equilibrium (i.e.: price and quantity) given a pair of quadratic demand and supply functions.

Use MS-Excel as a support tool to solve a represent quadratic and cubic exercises.

Book Chapters: Mathematics for Economics and Business. Section 2.1. (See Bibliography)

Video: Session 7 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 7" list of exercises (Available on IE Campus).

SESSION 8 (LIVE IN-PERSON)

Revenue, Cost and Profit.

Learning goals:

- Introduction, definition and construction of the revenue, cost and profit functions.
- Sketch the graphs of the total revenue, total cost, average revenue, average cost and profit function (EXCEL).
- Find the level of output that maximizes total revenue.
- Find the level of output that maximizes profit.
- Find the break-even levels of output.

Book Chapters: Mathematics for Economics and Business. Section 2.2. (See Bibliography)

Video: Session 8. (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 8" list of exercises (Available on IE Campus).

SESSION 9 (LIVE IN-PERSON)

Indices and logarithms

Learning goals:

- Evaluate b^n when n is positive, negative, a whole number or a fraction.
- Simplify algebraic expressions using the rules of indices.
- Returns to scale of a production function.
- Evaluate logarithms in simple cases.
- Use the rules of logarithms to solve equations in which the unknown occurs as a power.

Book Chapters: Mathematics for Economics and Business. Section 2.3. (See Bibliography)

Video: Session 9 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade. After the session, you should work on the "Session 9" list of exercises (Available on IE Campus).

SESSION 10 (LIVE IN-PERSON)

The exponential and natural logarithms functions ($\ln x$).

Learning goals:

- Sketch graphs of general exponential functions.
- Modelling growth and decay
- Use the $y = \ln x$ to solve equations.

Book Chapters: Mathematics for Economics and Business. Section 2.4 (See Bibliography)

Video: Session 10 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 10" list of exercises (Available on IE Campus).

SESSION 11 (ASYNCHRONOUS)

In this session, you will solve a set of questions covering contents from sessions 1-10.

Learning goals:

- Review the topics studied in previous sessions.
- Working to practice for the midterm exam.

During this session, you will work at home to solve some exercises. Be aware that the exercises will be available online for a short period.

PART II: COMPARATIVE STATIC ANALYSIS

Comparative statics in Economics is the comparison of two different economic outcomes, before and after a change in some underlying exogenous parameter. Comparative statics is commonly used to study changes in supply and demand when analyzing a single market, and to study changes in policies when analyzing the whole economy.

SESSION 12 (LIVE IN-PERSON)

Derivatives. Rules of Differentiation

Learning goals:

- The derivative of a function. The slope of a tangent.
- Lagrange ($f'(x)$) and Leibniz (dy/dx) notations for the derivative.
- Differentiate power functions.
- The constant rule to differentiate $y = c + f(x)$ vs $y = c \cdot f(x)$
- The sum (difference rule to differentiate $y = f(x) \pm g(x)$)

- Evaluate and interpret second order derivatives.

Book Chapters: Mathematics for Economics and Business. Sections 4.1 and 4.2. (See Bibliography)

Video: Session 12 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 12" list of exercises (Available on IE Campus).

SESSION 13 (LIVE IN-PERSON)

MID-TERM EXAM.

The mid-term exam will take place on Session #13, and it is worth 20% of the overall grade. This exam will be deployed through IE Campus, and it will take 30 minutes.

No calculators are allowed. You may use EXCEL and EMATH HELP.

SESSION 14 (LIVE IN-PERSON)

Marginal functions.

Learning goals:

- Calculate marginal revenue and marginal cost.
- Derive the relationship between marginal and average revenue.
- Calculate marginal product of labor.
- State the law of diminishing marginal productivity.
- Calculate the marginal propensity to consume and marginal propensity to save.

Book Chapters: Mathematics for Economics and Business.. Section 4.3. (See Bibliography)

Video: Session 14 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 14" list of exercises (Available on IE Campus).

SESSION 15 (LIVE IN-PERSON)

Further rules of differentiation.

Learning goals:

- Differentiate the exponential and the natural logarithm functions.
- Use the chain rule to differentiate a function of a function.
- Use the product rule to differentiate the product of two functions.
- Use the quotient rule to differentiate the quotient of two functions.

- Using combinations of differentiation rules.

Book Chapters: Mathematics for Economics and Business. Section 4.4.. (See Bibliography)

Video: Session 15 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 15" list of exercises (Available on IE Campus).

SESSION 16 (LIVE IN-PERSON)

Applications of the derivative to real-life problems: Elasticity.

- Price elasticity (point and arc)
- Decide whether a supply and demand function are inelastic, unit elastic or elastic.
- Understand the relationship between price elasticity of demand and revenue.
- Price elasticity for general linear demand functions.

Book Chapters: Mathematics for Economics and Business. Section 4.5. (See Bibliography)

Video: Session 16. (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 16" list of exercises (Available on IE Campus).

SESSION 17 (LIVE IN-PERSON)

Applications of the derivative to real-life problems: Optimisation of economic functions.

Learning goals:

- Use the first-order derivative to find the stationary points of a function.
- Use the second-order derivative to classify the stationary points of a function.
- Find the maximum and minimum points of an economic function.
- Use the stationary points to sketch graphs of economic functions.

Book Chapters: Mathematics for Economics and Business. Section 4.6. (See Bibliography)

Video: Session 17. (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 17" list of exercises (Available on IE Campus).

SESSION 18 (LIVE IN-PERSON)

Further optimisation of economic functions.

Learning goals:

- Show that, at the point of maximum profit, marginal revenue equals marginal costs.
- Show that, at the point of maximum profit, the slope of the marginal revenue curve is less than that of marginal cost.
- Maximise profit of a firm with and without price discrimination in different markets.
- Show that, at the point of maximum average product of labour, average product of labour equals marginal product of labour.

Book Chapters: Mathematics for Economics and Business. Section 4.7. (See Bibliography)

Video: Session 18. (available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 18" list of exercises (Available on IE Campus).

SESSION 19 (LIVE IN-PERSON)

Functions of several variables. Partial differentiation.

Learning goals:

- Use the function notation $z = f(x,y)$
- Determine the first-order partial derivatives, f_x and f_y
- Determine the second order partial derivatives, f_{xx} , f_{xy} , f_{yx} , and f_{yy}
- Use the small increments formula
- Perform implicit differentiation

Book Chapters: Mathematics for Economics and Business. Section 5.1. (See Bibliography)

Video: Session 19. (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 19" list of exercises (Available on IE Campus).

SESSION 20 (LIVE IN-PERSON)

Partial elasticity and marginal functions.

Learning goals:

- Calculate partial elasticities
- Calculate marginal utilities
- Calculate the MRS (marginal rate of substitution along an indifference curve).
- Calculate marginal products.
- Calculate the MRTS (marginal rate of technical substitution along an isoquant)
- Euler's theorem.

Book Chapters: Mathematics for Economics and Business. Section 5.2 (See Bibliography)

Video: Session 20 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 20" list of exercises (Available on IE Campus).

SESSION 21 (ASYNCHRONOUS)

In this session, you will solve a set of questions covering contents from sessions 14-20.

Learning goals:

Review the topics studied in previous sessions.

Working to practice for the final exam.

During this session, you will work at home to solve some exercises. Be aware that the exercises will be available online for a short period.

SESSION 22 (LIVE IN-PERSON)

Unconstrained optimization.

Learning goals:

- Use the first-order partial derivatives to find the stationary points of a function of two variables.
- Use the second-order partial derivatives to classify the stationary points of a function of two variables.
- Firm the maximum profit of a firm that produces two goods.
- Other optimization problems.

Book Chapters: Mathematics for Economics and Business. Section 5.4. (See Bibliography)

Video: Session 22 (available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 22" list of exercises (Available on IE Campus).

SESSION 23 (LIVE IN-PERSON)

Constrained optimization.

Learning goals:

- Give a graphical interpretation of constrained optimisation.
- Use the method of Lagrange multipliers to solve constrained optimization problems.
- Give an economic interpretation of Lagrange multipliers.
- Use Lagrange multipliers to maximise a Cobb-Douglas production function subject to a cost constraint.
- Use Lagrange multipliers to maximise a utility production function subject to a budgetary constraint.

Book Chapters: Mathematics for Economics and Business. Sections 5.5 and 5.6. (See Bibliography)

Video: Session 23 (available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 23" list of exercises (Available on IE Campus).

SESSION 24 (LIVE IN-PERSON)

Constrained optimisation (cont.)

- Show that when a firm maximises output subject to a cost constraint, the ratio of marginal product to price is the same for all inputs.
- Show that when a consumer maximises utility subject to a budgetary constraint, the ratio of marginal utility to price is the same for all goods.
- Constrained optimisation subject to inequality constraints (Karush-Khun-Tucker)

Book Chapters: Mathematics for Economics and Business. Chapters 5.5 and 5.6. (See Bibliography)

Video: Session 24 (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 24" list of exercises (Available on IE Campus).

SESSION 25 (LIVE IN-PERSON)

Linear programming

Learning goals:

- Graphical solutions of linear programming problems.
- Apply SOLVER to linear programming problems.
- Some applications of linear programming.

Book Chapters: Mathematics for Economics and Business. Sections 8.1 and 8.2. (See Bibliography)
Video: Session 25 (available on IE Campus)

Video: Video : How to use SOLVER for LP (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 25" list of exercises (Available on IE Campus).

SESSION 26 (LIVE IN-PERSON)

Case: Solving real-life problems (Dealing with budget constraints).

Learning goals:

- Apply SOLVER to linear programming problems.
- Identify the objective and constraint functions of a real-life problem.
- Interpret the results.

Book Chapters: Microsoft Excel 2016 Data Analysis and Business Modeling. Chapters 29, 30 (IE Library)

Video: Some examples using SOLVER for LP (Available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

PART III. DINAMYC ANALYSIS

In this part, we learn some tools for analysis of the time evolution of several economic problems.

SESSION 27 (LIVE IN-PERSON)

Indefinite integration.

Learning goals:

- Recognise the notation for indefinite integration.
- Solve the integrals from simple powers and exponentials.
- Integrate functions of the form $a \cdot f(x) + b \cdot g(x)$
- Find the total cost function given any marginal cost function.
- Find the total revenue function given any marginal revenue function.
- Find other total functions.

Book Chapters: Mathematics for Economics and Business. Section 6..1 (See Bibliography)

Video: Session 27. Available on IE Campus.

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 27" list of exercises (Available on IE Campus).

SESSION 28 (LIVE IN-PERSON)

Definite integration.

Learning goals:

- Recognise the notation for indefinite integration.
- Evaluate definite integrals in simple cases.
- Some applications of integration (Capital stock formation, present value of a continuous revenue stream).

Book Chapters: Mathematics for Economics and Business. Section 6.2. (See Bibliography)

Video: Session 28. (available on IE Campus)

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 28" list of exercises (Available on IE Campus).

SESSION 29 (LIVE IN-PERSON)

Consumer and producer surplus.

Learning goals:

- Calculate the consumer surplus for linear and non-linear demand functions.
- Calculate the producer surplus for linear and non-linear supply functions.

Book Chapters: Mathematics for Economics and Business. Section 6.2. (See Bibliography)

Video: Session 29. Available on IE Campus.

Before the session, you must watch the video announced in Campus online (using the link published in Campus) or read the "Pre-read materials" as published in Campus online, including the Worked Exercises published in the book.

Failing to complete the "Before the session" activities will negatively impact your ability to follow the session, and therefore it could affect your continuous grading results.

During the session: you'll be asked to complete some quizzes about the subject in scope. The grade corresponding to the delivery of these exercises will be part of your class contribution grade.

After the session, you should work on the "Session 29" list of exercises (Available on IE Campus).

SESSION 30 (LIVE IN-PERSON)

FINAL EXAM.

It is worth 35% of the overall grade. You need to score at least 3.5 on the final exam to pass the general course, even if you have already passed the continuous evaluation (i.e., class participation, homework, and midterm exam). The final exam will be deployed through IE Campus, and it will take 60 minutes.

The exam covers the whole subject. and it will consist of 5 questions worth 2 points each, plus a bonus question that allows you to get an extra point. Hence, in this exam, you may get up to 11 points out of 10.

No calculators are allowed. You may use EXCEL and EMATH HELP.

BIBLIOGRAPHY

Compulsory

- Ian Jacques. (2018). *Mathematics for Economics and Business*. 1st. Pearson. ISBN 9781292191669 (Digital)

Recommended

- Winston, Wayne L.. (2016). *Microsoft Excel 2016 Data Analysis and Business Modeling*. Microsoft Press/Pearson. ISBN 9789462390362 (Digital)

A soft copy of chapters 29, 30 and 31 will be uploaded on IE Campus

- Alpha C. Chiang and Kevin Wainwright. (2004). *Fundamental Methods of Mathematical Economics*. 4th. Mc Graw Hill. ISBN 9780070109100 (Printed)

EVALUATION CRITERIA

Your final grade in the course will be based on both individual and group work of different characteristics that will be weighted in the following way:

Criteria	Percentage	Comments
Quizzes, Participation ...	20 %	Face to Face Sessions
Homework	25 %	Online exercises
Mid-Term Exam	20 %	Session #13
Final Exam	35 %	Session #30

A. CLASS PARTICIPATION

It will be worth **20% of the overall grade** - students are expected to come prepared and participate actively (and voluntarily) during lectures. Your class grade will be based on your responses to the Quizzes that you will take during the face-to-face sessions. The class participation grade will also consider other aspects such as attendance, punctuality, and class conduct. There will be penalties for those who disturb their classmates or the professor, talk excessively, or use electronic devices for non-academic purposes (i.e., Whatsapp, Instagram, etc.). The results of the group case activities organized during session #4 will be considered a bonus grade that will be put on top of your final grade.

B. HOMEWORK

It is worth **25% of the final grade**. There will be a problem set assigned for each session. Each problem set will be graded after the due date. Be aware there won't be exceptions or deadlines changes. If you miss a due date, your grade for the assignment will be 0 points. However, before computing your overall "Homework" grade we will exclude the worst FOUR scores over the semester.

C. MIDTERM

The mid-term exam will take place on Session #13, and it is worth **20% of the overall grade**. This exam will be deployed through IE Campus, and it will take 35 minutes. It will consist of THREE questions.

D. FINAL EXAM

It is worth **35% of the overall grade**. You need to score at least 3.5 on the final exam to pass the general course, even if you have already passed the continuous evaluation (i.e., class participation, homework, and midterm exam). The final exam will be deployed through IE Campus, and it will take 60 minutes.

The exam covers the whole subject. and it will consist of 5 questions worth 2 points each, plus a bonus question that allows you to get an extra point. Hence, in this exam, you may get up to 11 points out of 10.

No calculators are allowed. You may use EXCEL and EMATH HELP.

- Sobresaliente/Outstanding: 9.0-10.0 (A to A+)
Consistently produces work of the highest quality and craft; exhibits notable progress and development over the course of the semester; meets all course objectives at the highest level; attendance is near-perfect, and contributions to course discussions are extremely valuable.
- Notable: 7.0-8.9 (B to B+)
Completes all assignments with work of above-average quality and craft; exhibits significant progress and development; meets most course objectives; attendance and participation are very good.
- Aprobado: 6.0-7.0 (C to C+)
Completes all assignments with work of acceptable quality and craft; exhibits some progress and development; meets a majority of course objectives. Attendance and participation are acceptable.
- Aprobado: 5.0-6.0 (D)
Assignments are delivered but are incomplete and/or of low quality and craft; exhibits little progress and development; meets few course objectives. Attendance and participation are poor, but absences do not total more than 30%.
- Suspenso: 0-4.9 (F)
Work is incomplete, missing, or does not meet course objectives. Attendance and participation are poor.
- Automatic Failure/Suspenso: 0 (F)
Please, note that a student who misses 30% or more of the scheduled sessions receives an automatic 0.0, and loses his or her right to the second "convocatoria."

GENERAL OBSERVATIONS

Each student has four attempts over two consecutive academic years to pass this course.

For every BIR Program mandatory class aside from the IR Unplugged and BIR Electives, students are required to obtain the minimum grade of 5 required to pass the course. Students whose grade in the Final Exam (or the largest assignment) is below 5 will fail the course. The rule applies to whichever assignment carries the greatest weight to the final grade. Dates and location of the final exam will be posted in advance and will not be changed.

Students must attend at least 70% of the sessions. Students who do not comply with the 70% attendance rule will receive a 0.0 on their first and second attempts and go directly to the third one (they will need to enroll in this course again the following academic year).

Students who are in the third or fourth attempt must contact the professor during the first two weeks of the course.

ATTENDANCE

In-person attendance is mandatory at IE University, as it is an essential factor of IE's learning methodology. While we do closely monitor attendance in each course, we also consider our students responsible for their own agenda and commitments, as adult university students. With that in mind, each student may miss up to 30% of the sessions within a given course and still maintain the possibility of passing that given course. This 30% "buffer" is to be used for any absences, such as: illnesses, personal emergencies, commitments, official/governmental matters, business and/or medical appointments, family situations, etc. Students should manage their various needs, and situations that may arise, within that 30% buffer. If a student is absent to more than the allowed 30% of the sessions (regardless of the reason), s/he will obtain a 0.0 grade for that course in both the ordinary and extraordinary calls of the current academic year, and s/he will have to retake the course during the following academic year.

Please pay close attention to your attendance. The program strongly encourages attending 100% of the sessions as it will improve your learning outcomes, it will increase the class performance and it will benefit your participation grade. Noncompliance with deadlines for Non-Classroom Learning activities or assignments will result in an absence for the session.

Extreme cases involving emergencies such as: extended hospitalizations, accidents, serious illnesses and other cases of force majeure, are to be consulted with the Program Management (bir.biemadrid@ie.edu) for assessment of the situation and corresponding documentation, in order to support and guide each student optimally.

For more information about the university attendance policy, please check; <https://www.ie.edu/student-guide/bir/policies-and-guidelines/attendance/>

RETAKE POLICY

Any student whose weighted final grade is below 5 will be required to sit for the retake exam to pass the course (except those not complying with the attendance rules, whom are banned from this possibility).

Grading for retakes will be subject to the following rules:

- The retakes will consist of a comprehensive exam or equivalent assignment. The grade will depend only on the performance on this exam; continuous evaluation over the semester will not be taken into account.
- Dates and location of the retakes will be posted in advance and will not be changed.
- The exam/assignment will be designed bearing in mind that the passing grade is 5 and the maximum grade that can be attained is 8 out of 10.

The third attempt final grade will be computed as follows:

Homework: (Only sessions #11 and #21) (20 %)

Midterm (35%)

Final exam (45%)

To pass the subject in this attempt, you need a minimum grade of 5 points in the retake. Be aware that you need to score at least 3.5 on the final exam to pass the overall course, even if you have already passed the course through the other course assessments.

PLAGIARISM / ACADEMIC HONESTY

Plagiarism is the dishonest act of presenting another person's ideas, texts, or words as your own. This includes in order of the seriousness of the offense:

- providing faulty sources;
- copy-pasting material from your own past assignments (self-plagiarism) without the instructor's permission;

- copy-pasting material from external sources even while citing them;
- using verbatim translations from sources in other languages without citing them;
- copy-pasting material from external sources without citing them;
- and buying or commissioning essays from other parties.

IEU students must contact the professor if they don't know whether the use of a document constitutes plagiarism. For help with your academic writing, contact the Writing Center (writingcenter@faculty.ie.edu). The professor will also advise the student on how to present said material. All written assignments must be submitted through Turn-it-in, which produces a similarity report and detects cases of plagiarism. Professors are required to check each student's academic work in order to guarantee its originality. If the originality of the academic work is not clear, the professor will contact the student in order to clarify any doubts. Students using external tutorial support should report it to the professor and the BIR Program from the moment they began receiving this support. In the event that the meeting with the student fails to clarify the originality of the academic work, the professor will inform the Director of the Bachelor Program about the case, who will then decide whether to bring the case forward to the BIR Academic Review Panel. Very high similarity scores will be automatically flagged and forwarded to the Academic Review Panel. Plagiarism constitutes a very serious offense and may carry penalties ranging from getting a zero for the assignment to expulsion from the university depending on the severity of the case and the number of times the student has committed plagiarism in the past.

PROFESSOR BIO

Professor: **ANTONIO GARCIA ROMERO**

E-mail: agr22@faculty.ie.edu

ANTONIO GARCIA ROMERO

ACADEMIC BACKGROUND

Ph.D. in Economics and Business Administration, Universidad Autónoma de Madrid, Spain, 2002

Master in Management of Innovation, Universidad Carlos III de Madrid, Spain, 1993

BSc. in Theoretical Physics, Universidad de Granada, Spain, 1991

ACADEMIC EXPERIENCE

Assistant Professor. Area of Operations and Technology, IE Business School, Spain, 2015-Present

Coordinator of Mathematics, IE University, 2014-present

Adjunct Professor. IE University, 2013-2015

Adjunct Professor. Dept. Economics, U. Carlos III de Madrid, Spain, 1998-2003 and 2008-2013

Adjunct Professor. U. Europea de Madrid, Spain, 2005-2007

Adjunct Professor. UOC, Spain, 2000-2003

BUSINESS EXPERIENCE

Consultant in Healthcare Innovation, 2013-present

Head of Biomedical Research Policy Unit, Ministry of Health, Regional Government of Madrid, Spain, 2003-2013

LATEST PUBLICATIONS

García-Romero, A, A. Escribano, and J.A. Tribó. 2017. The Impact of Health Research on Length of Stay in Spanish Public Hospitals. *Research Policy*, 46(3): 591-604 (FT50)

García-Romero A, D. Santín, and G. Sicilia. 2016. Another brick in the wall. A new Ranking of Academic Journals in Economics using FDH. *Scientometrics*, 97(1): 91-101

García-Romero A and JM. Estrada. 2014. A bibliometric analysis of plagiarism and self-plagiarism through Déjà vu. *Scientometrics*, 101(1):381-396.

OTHER INFORMATION

I will be pleased to meet students either on Campus premises or via Zoom upon request. Please, tell me in class or preferably send me an email to the following address: agr22@faculty.ie.edu. Do not forget to specify your degree and group. I will only answer requests sent with the IE student email account.

