Recommended Readings in Math and Programming before Pursuing the MQF Program

Rutgers Business School
Master of Quantitative Finance Program

Section I Basic Knowledge of Mathematics

1. Calculus

Reference Book: ***Calculus***, Gilbert Strang, Wellesley-Cambridge Press

1.1. Derivatives (Chapter 2)
Derivative of a function; linear approximation; product, quotient and power rules.

1.2. Applications of the Derivative (Chapter 3)
Linear approximation; maximum and minimum problems; second derivatives; the mean value theorem and L'hopital's rule.

1.3. The Chain Rule (Chapter 4)
The chain rule; implicit differentiation and related rates; inverse functions and their derivatives.

1.4. Integrals (Chapter 5)
Indefinite integrals and substitutions; the definite integral; the fundamental theorem and its applications; numerical integration.

1.5 Exponentials and Logarithms (Chapter 6)
The exponential e^x; logarithms; powers instead of exponentials; Euler's method.

1.6 Techniques of Integration (Chapter 7)
Integration by parts.

1.7 Applications of the Integral (Chapter 8)
Probability and calculus; masses and moments.

1.8 Polar Coordinates and Complex Numbers (Chapter 9)
Polar coordinates; complex numbers.

1.9 Infinite Series (Chapter 10)
The geometric series; the Taylor series; power series.

1.10 Vectors and Matrices (Chapter 11)
Vectors and dot products; planes and projections; cross products and determinants; matrices and linear equations.

1.11 Partial Derivatives (Chapter 13)
Partial derivatives; tangent planes and linear approximations; gradients; the chain rule; maximum, minimum and saddle points; constraints and Lagrange multipliers.

1.12 Multiple Integrals (Chapter 14)
Double integrals; changing to better Coordinates; triple Integrals; cylindrical and spherical coordinates.

1.13 Vector Calculus (Chapter 15)
Green's theorem; surface integrals; the divergence theorem; Stokes' theorem

2. Linear Algebra

Reference Book: ***Linear Algebra***, David Cherney, Tom Denton and Andrew Waldron
Davis California, 2013. First Edition

2.1 Systems of Linear Equations (Chapter 2)
Gaussian elimination; elementary row operations; solutions sets for systems of linear equations.

2.2 Vectors in Space, n-Vectors (Chapter 4)
Addition and scalar multiplication in R^n; hyperplanes; directions and magnitudes; vectors, lists and functions

2.3 Linear Transformations (Chapter 6)
The consequence of linearity; linear functions on hyperplanes; linear differential operators; bases.

2.4 Matrices (Chapter 7)
Linear transformations and matrices; properties of matrices; inverse matrix; LU decomposition.

2.5 Determinants (Chapter 8)
The determinant formula; elementary matrices and determinants; properties of the determinant.

2.6 Subspaces and Spanning Sets (Chapter 9)
Subspaces; building subspaces.

2.7 Linear Independence (Chapter 10)
Showing linear dependence; showing linear independence

2.8 Basis and Dimension (Chapter 11)
Bases in R^n; matrix of a linear transformation.

2.9 Eigenvalues and Eigenvectors (Chapter 12)
Invariant directions; the eigenvalue-eigenvector equation; eigenspaces.

2.10 Diagonalization (Chapter 13)
Change of basis; changing to a basis of eigenvectors.

2.11 Orthonormal Bases and Complements (Chapter 14)
QR Decomposition; orthogonal complements.

3. Probability and Statistics

Reference Book: ***Probability and Statistics with R***, Chapman and Hall, CRC Press 2008.
Note: Students are recommended to study probability and statistics by using R.

3.1 A Brief Introduction to S(R). (Chapter 1).

R structures; data types in R; reading and outputting data; all data structures in R; how to write your own functions in R.

3.2 Exploring Data. (Chapter 2).

Displaying qualitative and quantitative data; summary measures of location and spread; bivariate and multivariate data.

3.3 General Probability and Random Variables (Chapter 3).

Sample space; set theory; conditional probability; the law of total probability and Bayes' rule; independent events; discrete random variables; mode, median and percentiles; expected values of discrete random variables; moments; continuous random variables; Markov's theorem and Chebyshev's inequality; weak law of large numbers; skewness; moment generating functions.

3.4 Univariate Probability Distributions (Chapter 4).

Discrete univariate distributions; continuous univariate distributions.

3.5 Multivariate Probability Distributions (Chapter 5).

Joint distribution of two random variables; independent random variables; conditional distributions; expected values, covariance and correlation; multinomial distribution; bivariate normal distribution.

3.6 Sampling and Sampling Distributions (Chapter 6).

Sampling; Chi-square distribution; t-distribution; F-distribution.

3.7 Point Estimation (Chapter 7)

Mean square error; unbiased estimators; efficiency; consistent estimators; method of moments estimators; maximum likelihood estimators.

3.8 Confidence Intervals (Chapter 8)

Confidence intervals for population means and variances; confidence intervals based on large samples.

3.9 Hypothesis Testing (Chapter 9)

Type I and Type II errors; power function; UMP test; P-value; tests of significance; hypothesis tests for population means/variances/proportions.

3.10 Nonparametric Methods (Chapter 10)

Goodness-of-fit tests (Chi-square/KS tests); bootstrapping.

3.11 Regression (Chapter 12)

Simple linear regression; multiple linear regression; OLS; properties of the fitted regression line; ANOVA approach to regression (SSR, SSE, SST and degrees of freedom); R square; T test; F test.

4. Differential Equations

Reference book: ***Introduction to Differential Equations***, Jeffrey R. Chasnov, The Hong Kong University of Science and Technology.

4.1 Introduction to ODEs (Chapter 1).
4.2 First-order ODEs (Chapter 2).
4.3 Second-order ODEs (Chapter 3).
4.4 The Laplace Transform (Chapter 4).
4.5 Series Solutions (Chapter 5).
4.6 Systems of Equations (Chapter 6).
4.7 Nonlinear Differential Equations (Chapter 7).
4.8 Partial Differential Equations (Chapter 8).

Section II Coding Skills

5. C++

Reference book: ***C++ for Programmers*****,** Paul J. Deitel and Harvey M. Deitel.

5.1 Introduction to C++ Programming (Chapter 2)
5.2 Introduction to Classes and Objects (Chapter 3)
Classes; Objects; Member functions; Data members
5.3 Control Statements (Chapters 4&5)
5.4 Functions and an Introduction to Recursion (Chapter 6)
5.5 Arrays and Vectors (Chapter 7)
5.6 Pointers and Pointer-based Strings (Chapter 8)
5.7 Classes: A Deeper look (Chapters 9&10)
5.8 Operator Overloading: String and Array Objects (Chapter 11)
5.9 Inheritance (Chapter 12)
5.10 Polymorphism (Chapter 13)
5.11 Templates (Chapter 14)
5.12 Standard Template Library (Chapter 20)

6. Matlab

Reference book: ***Numerical Methods in Finance and Economics – A MATLAB-Based Introduction (Second Edition)***, Paolo Brandimarte, WILEY.

7. SAS

Reference book: ***The Little SAS Book,*** Lora D. Delwiche and Susan J. Slanghter, SAS Publishing.

8. R

Reference books:
An Introduction to R, W. N. Venables, D. M. Smith and the R Development Core Team.
Probability and Statistics with R, Chapman and Hall, CRC Press 2008.
Time Series Analysis and Its Applications with R Examples**,** Robert H. Shumway and David S. Stoffer, Springer**.**

9. VBA

Reference books:
Financial Modeling Using Excel and VBA, Chandan Sengupta, WILEY.
Advanced Modeling in Finance Using Excel and VBA, Mary Jackson and Mike Staunton, John Wiley & Sons, Ltd.