Financial Mathematics Exam—October 2023

The Financial Mathematics exam is a 2.5-hour exam that consists of 30 multiple-choice questions and is administered as a computer-based test (CBT). For additional details, please refer to Exam Rules

The goal of the syllabus for this examination is to provide an understanding of the fundamental concepts of financial mathematics, and how those concepts are applied in calculating present and accumulated values for various streams of cash flows as a basis for future use in: reserving, valuation, pricing, asset/liability management, investment income, capital budgeting, and valuing contingent cash flows.

The Financial Mathematics Exam assumes a basic knowledge of calculus.

The following learning objectives are presented with the understanding that candidates are allowed to use specified calculators on the exam. The education and examination of candidates reflects that fact. In particular, such calculators eliminate the need for candidates to learn and be examined on certain mathematical methods of approximation.

Please check the Updates section on this exam's home page for any changes to the exam or syllabus.

Each multiple-choice problem includes five answer choices identified by the letters A, B, C, D, and E, only one of which is correct. Candidates must indicate responses to each question on the computer. Candidates will be given 2.5 hours to complete the exam.

As part of the computer-based testing process, a few pilot questions will be randomly placed in the exam (paper and pencil and computer-based forms). These pilot questions are included to judge their effectiveness for use on future exams, but they will NOT be used in the scoring of this exam. All other questions will be considered in the scoring. All unanswered questions are scored incorrect. Therefore, candidates should answer every question on the exam. There is no set requirement for the distribution of correct answers for the multiple-choice preliminary examinations. It is possible that a particular answer choice could appear many times on an examination or not at all. Candidates are advised to answer each question to the best of their ability, independently from how they have answered other questions on the examination.

Since the CBT exam will be offered over a period of a few days, each candidate will receive a test form composed of questions selected from a pool of questions. Statistical scaling methods are used to ensure within reasonable and practical limits that, during the same testing period of a few days, all forms of the test are comparable in content and passing criteria. The methodology that has been adopted is used by many credentialing programs that give multiple forms of an exam.

The ranges of weights shown in the Learning Objectives below are intended to apply to the large majority of exams administered. On occasion, the weights of topics on an individual exam may fall outside the published range. Candidates should also recognize that some questions may cover multiple learning objectives.

LEARNING OBJECTIVES

1. **Time Value of Money (5-15%)**
Learning Objectives
The Candidate will understand and be able to perform calculations relating to present value, current value, and accumulated value.
Learning Outcomes
The Candidate will be able to: a) Define and recognize the definitions of the following terms: interest rate (rate of interest), simple interest, compound interest, accumulation function, future value, current value, present value, net present value, discount factor, discount rate (rate of discount), convertible m-thly, nominal rate, effective rate, inflation and real rate of interest, force of interest, equation of value. b) Given any three of interest rate, period of time, present value, and future value, calculate the remaining item using simple or compound interest. Solve time value of money equations involving variable force of interest. c) Given any one of the effective interest rate, the nominal interest rate convertible m-thly, the effective discount rate, the nominal discount rate convertible m-thly, or the force of interest, calculate any of the other items. d) Write the equation of value given a set of cash flows and an interest rate.

2. **Topic: Annuities/cash flows with non-contingent payments (20-30%)**

Learning Objectives

The Candidate will be able to calculate present value, current value, and accumulated value for sequences of non-contingent payments.

Learning Outcomes

The Candidate will be able to:

a) Define and recognize the definitions of the following terms:
annuity-immediate, annuity due, perpetuity, payable m-thly or payable continuously, level payment annuity, arithmetic increasing/decreasing annuity, geometric increasing/decreasing annuity, term of annuity.

b) For each of the following types of annuity/cash flows, given sufficient information of immediate or due, present value, future value, current value, interest rate, payment amount, and term of annuity, calculate any remaining item.

- Level annuity, finite term.
- Level perpetuity.
- Non-level annuities/cash flows.
  - Arithmetic progression, finite term and perpetuity.
  - Geometric progression, finite term and perpetuity.
  - Other non-level annuities/cash flows.

3. **Topic: Loans (15-25%)**

Learning Objectives

The Candidate will understand key concepts concerning loans and how to perform related calculations.

Learning Outcomes

The Candidate will be able to:

a) Define and recognize the definitions of the following terms: principal, interest, term of loan, outstanding balance, final payment (drop payment, balloon payment), amortization.

b) Calculate:

- The missing item, given any four of: term of loan, interest rate, payment amount, payment period, principal.
- The outstanding balance at any point in time.
- The amount of interest and principal repayment in a given payment.
- Similar calculations to the above when refinancing is involved.

4. **Topic: Bonds (15-25%)**

Learning Objectives

The Candidate will understand key concepts concerning bonds, and how to perform related calculations.

Learning Outcomes

The Candidate will be able to:

a) Define and recognize the definitions of the following terms: price, book value, market value, amortization of premium, accumulation of discount, redemption value, par value/face value, yield rate, coupon, coupon rate, term of bond, callable/non-callable, call price, call premium, accumulated value with reinvestment of coupons.

b) Given sufficient partial information about the items listed below, calculate any of the remaining items

- Price, book value, market value, accumulated value with reinvestment of coupons, amortization of premium, accumulation of discount. (Note that valuation of bonds between coupon payment dates will not be covered).
- Redemption value, face value.
- Yield rate.
- Coupon, coupon rate.
- Term of bond, point in time that a bond has a given book value, amortization of premium, or accumulation of discount.

c) Calculate the price of a callable bond to achieve a specified minimum yield

5. **Topic: General Cash Flows, Portfolios, and Asset Liability Management (20-30%)**

Learning Objectives

The Candidate will understand key concepts concerning yield curves, rates of return, measures of duration and convexity, cash flow matching and immunization, and how to perform related calculations.

Learning Outcomes

The Candidate will be able to:

a) Define and recognize the definitions of the following terms: yield rate/rate of return, current value, duration and convexity (Macaulay and modified), portfolio, spot rate, forward rate, yield curve, cash flow and duration matching, and immunization (including full immunization and Redington immunization).

b) Calculate:

- The duration and convexity of a set of cash flows.
- Either Macaulay or modified duration given the other.
- The approximate change in present value due to a change in interest rate,
  - Using 1st-order linear approximation based on modified duration.
  - Using 1st-order approximation based on Macaulay duration.
- The present value of a set of cash flows, using a yield curve developed from forward and spot rates.

c) Construct an investment portfolio to:

- Protect the value of an asset-liability portfolio using either Redington or full immunization
- Exactly match a set of liability cash flows.

Text References

Knowledge and understanding of the financial mathematics concepts are significantly enhanced through working out problems based on those concepts. Thus, in preparing for the Financial Mathematics exam, whichever of the source textbooks candidates choose to use, candidates are encouraged to work out the textbook exercises related to the listed readings.

Suggested Textbooks

There is not a single textbook required for the learning objectives in Section I. The texts listed below are representative of the textbooks available to cover the material on which the candidate may be tested. Not all topics may be covered at the same level in each text. Listed sections may include introductory material, summary material, and problems that are not part of the learning objectives. The candidate may wish to use one or more texts in his/her preparation for the examination.

Broverman, S.A., Mathematics of Investment and Credit (Seventh Edition), 2017, ACTEX Publications, ISBN 978-1-63588-221-6
Chapter 1 (excluding 1.2.1 and 1.8)
Chapter 2 (excluding 2.3.1.2, 2.4.2, 2.4.3 and 2.4.5)
Chapter 3 (excluding 3.2.1, 3.2.2, 3.3, and 3.4)
Chapter 4 (excluding 4.1.3, 4.1.4, and 4.4 is for background only)
Chapter 5 (excluding 5.2, the investment year method portion of 5.3.1, and excluding all of 5.3.2, 5.3.3 and 5.3.4)
Chapter 6 (excluding 6.2 and 6.4)
Chapter 7 (excluding 7.1.3, 7.1.6 and 7.3)
At various places in the sections of this text that are listed above there are statements indicating that more information is available in sections that are not listed above. Candidates are not responsible for this additional information.

Vaaler, L.J.F., Harper, S.K., and Daniel, J.W. Mathematical Interest Theory (Third Edition), 2019, The Mathematical Association of America, ISBN: 978-1-4704-4393-1:
Chapter 1 (excluding 1.13-1.16)
Chapter 2 (excluding 2.6)
Chapter 3 (excluding 3.10, 3.12, and the investment year method portion of 3.13)
Chapter 4
Chapter 5 (excluding 5.3)
Chapter 6 (excluding sections 6.6-6.7, example 6.8.1 and section 6.10)
Chapter 7 (excluding 7.2, 7.3, and 7.4)
Chapter 8 (8.3 only)
Chapter 9 (excluding 9.4, 9.5, and 9.7)

Brown, R and Kopp, S, *Financial Mathematics: Theory and Practice*, 2012, Reprint: ACTEX Learning, Published by McGraw-Hill Ryerson: ISBN: 978-1-63588-694-8:
Chapter 1, all sections
Chapter 2, sections 1, 2, 3
Chapter 3, all sections
Chapter 4, sections 1, 3, 4, 5
Chapter 5, sections 1, 2, 3
Chapter 6, sections 1, 2, 3, 4, 5, 6
Chapter 7, sections 1, 2
Chapter 8, all sections
Chapter 9, all sections

Francis, J. and Ruckman, C., Interest Theory – *Financial Mathematics and Deterministic Valuation*; (Third Edition), 2022, Actuarial Brew, ISBN 978-09981604-4-3
Chapters 1 to 13
Chapter 14 (excluding 14.04 and 14.05)
Chapters 15-16

[Candidates may also use Second Edition, 2018, Actuarial Brew, ISBN 978-0998160412 chapters listed below].
Chapters 1 to 9
Chapter 10 (excluding 10.03)
Chapter 11 (excluding 11.04)
Chapter 12 (excluding 12.02 and 12.03)
Chapter 13 (excluding 13.04-13.08)
Chapter 14 (excluding 14.04 and 14.05)
Chapter 15
Chapter 16

Chan, Wai-Sum, and Tse, Yiu-Kuen, *Financial Mathematics for Actuaries*, Third Edition 2022, World Scientific Publishing ISBN: 978-9811243271 (hard cover) or 978-9811245671 (paperback).
Chapter 1
Chapter 2 (excluding 2.4)
Chapter 3 (excluding 3.5)
Chapter 4 (excluding 4.2 and 4.5)
Chapter 5 (excluding 5.3)
Chapter 6 (excluding 6.4)
Chapter 7
Chapter 8 (excluding 8.6, 8.7 and 8.8)

ADDITIONAL REFERENCES

There is one study note that is required reading for this examination. This note can be downloaded from this document by clicking on the link.

- FM-24-17 Using Duration and Convexity to Approximate Change in Present Value. Sections 1-4 are required reading for this examination.

OTHER RESOURCES

Notation and terminology used for Exam FM

All released exam papers, since 2000, can be found here.

Sample Questions and Solutions (These documents and the online sample exam will continue to reflect the prior syllabus until after the August exam session is concluded. At that time, they will be updated to reflect the new syllabus.)

Review of Calculator Functions for the Texas Instruments BA-35

Review of Calculator Functions for the Texas Instruments BA II Plus

Although several different calculators are allowed for this exam, the BAII Plus or Plus Professional are strongly recommended due to their ability to solve for interest rates. There may be examination problems that require the BAII Plus or Plus Professional in order to find the answer.

Online Sample Exam FM

The Society of Actuaries (SOA) is interested in supporting candidates as they prepare for the preliminary exams. To that end the SOA has launched an online sample exam for Exam FM (Financial Mathematics). Available at no cost the sample exam selects questions and solutions in an online exam experience that resembles the computer-based testing employed for most of the SOA's preliminary exams. Questions have been coded to meet the Exam FM learning objectives and ensure candidates receive a balanced yet randomized set of questions each time they repeat the sample exam. The current set of questions is drawn from the existing set of sample questions.

Note: The text references, study notes, notation and terminology note, and other resources will not be available with the exam.