SOCIETY OF ACTUARIES

**Foundations of CFE Exam**

# Exam CFEFD

## AFTERNOON SESSION

**Date:** Wednesday, May 1, 2019
**Time:** 1:30 p.m. – 3:45 p.m.

## INSTRUCTIONS TO CANDIDATES

### General Instructions

1. This afternoon session consists of 5 questions numbered 8 through 12 for a total of 40 points. The points for each question are indicated at the beginning of the question. No questions pertain to the Case Study.

2. Failure to stop writing after time is called will result in the disqualification of your answers or further disciplinary action.

3. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions on the exam booklet.

### Written-Answer Instructions

1. Write your candidate number at the top of each sheet. Your name must not appear.

2. Write on only one side of a sheet. Start each question on a fresh sheet. On each sheet, write the number of the question that you are answering. Do not answer more than one question on a single sheet.

3. The answer should be confined to the question as set.

4. When you are asked to calculate, show all your work including any applicable formulas.

5. When you finish, insert all your written-answer sheets into the Essay Answer Envelope. Be sure to hand in all your answer sheets because they cannot be accepted later. Seal the envelope and write your candidate number in the space provided on the outside of the envelope. Check the appropriate box to indicate morning or afternoon session for Exam CFEFD.

6. Be sure your written-answer envelope is signed because if it is not, your examination will not be graded.

***Recognized by the Canadian Institute of Actuaries.***

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Exam CFEFD-Front Cover

****BEGINNING OF EXAMINATION****
**Afternoon Session**
***Beginning with Question 8***

**8.** (*7 points*)

(a) (*1 point*) Explain the difference between reporting risk and output risk.

Adam is an actuary at a very large organization. He developed a bivariate model to assess the combined capital required for risks A and B. Adam has been asked by the CRO to validate his risk model. Adam comments, "The model validation process is a waste of time and the model is solid. We only need to look at the model outputs and compare them to real world scenarios."

(b) (*2 points*) Critique Adam's statement.

A consultant has performed stress testing on the correlation between risks A and B in Adam's model. Her work produced the following outcomes:

| Scenario | Correlation between A and B | VaR 99.5% |
|---|---|---|
| Baseline | 0.05 | $9.4 million |
| Moderate | 0.10 | $10.3 million |
| Extreme | 0.80 | $142.6 million |

(c) (*2 points*)

(i) Interpret the results of the consultant's work.

(ii) State four questions that Adam should ask to validate his model in light of the consultant's information.

The CFO states, "Stress testing is very subjective, and outcomes cannot be validated. Therefore, it's difficult to manage our business based on results from stress testing."

(d) (*2 points*) Critique the CFO's statement on stress testing.

**9.** (*9 points*) The ALM team at Lambert Life models a product with the following features:

- A guarantee on the minimum credited rate, with the credited interest rate based on the 10-year government bond yield
- Policyholder can withdraw account value at any time, subject to a surrender charge but without a mark-to-market adjustment
- Unscheduled premiums are not allowed

The ALM model separately quantifies the cost of minimum interest rate guarantees and account value surrenders.

The CFO has set the hedge budget to cover extreme losses beyond the 95$^{th}$ percentile. The company expects to rebalance hedge portfolios every week given the volatile interest rate environment, but the existing ALM model cannot support weekly analysis.

An actuary on the ALM team suggests building a proxy model using replicating polynomials, considering three risk factors: mortality, interest rates and surrenders.

(a) (*1 point*) Describe two statistical tests that can measure the quality of fit for this proxy model.

(b) (*2 points*) Describe three criteria, other than quality of fit, to consider in designing the proxy model.

Each of the three risk factors was modeled with a quadratic function. In addition to the marginal risk functions, the model contains a 2$^{nd}$ order non-linear function that represents the interactions between interest rates and surrenders. A summary of the proxy model structure is given below.

| **Formula component** | **Number of components** | **Number of coefficients** |
|---|---|---|
| Constant | 1 | 1 |
| Quadratic marginal risk functions | 3 | 6 |
| 2-factor 2$^{nd}$ order non-linear interaction function | 1 | 4 |
| Total | 5 | 11 |

## 9. Continued

The CFO is concerned that hedge re-balancing based on the proxy model results will create volatility in income. He wants the cost of guarantees from the proxy model to be within 0.5% of the existing ALM model results.

The proxy model will be calibrated by regressing 20 scenario results against results from the existing ALM model. Calibration results are summarized below.

| | **Minimum interest rate guarantee** | **Market value losses on surrenders** |
|---|---|---|
| Root mean squared error | 2.1% | 0.7% |
| CTE(95) error | 0.1% | 1.3% |
| CTE(99) error | 1.6% | 0.8% |
| Maximum error | 42.7% | -1.3% |

(c) (*2 points*) Evaluate the proxy model fit with respect to the CFO's goals for hedging in:

(i) low interest rate environments.

(ii) high interest rate environments.

(d) (*2 points*) Recommend four improvements to the proxy model calibration to obtain a better fit. Justify your recommendation.

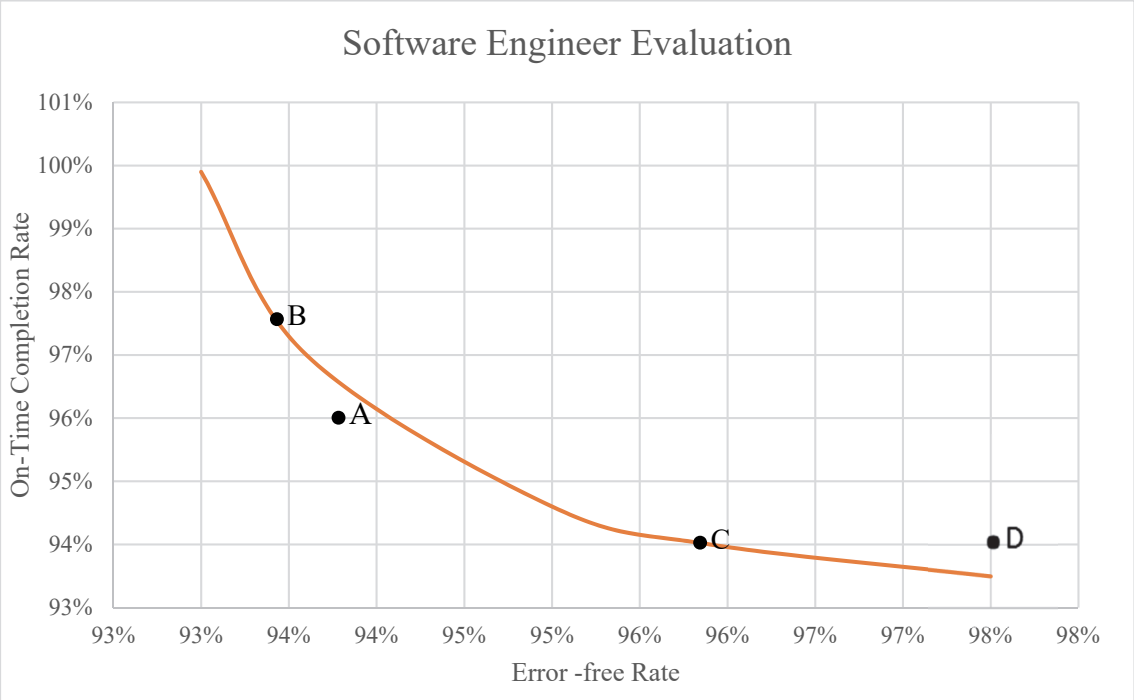
The proxy model calibration projects the average 10-year government bond yield to be 3% in one year. The CFO believes this yield will be 2% in one year. The actuary is charged with using the entropy technique to adjust the results to reflect the CFO's view.

(e) (*2 points*)

(i) Describe how the actuary would apply the entropy technique.

(ii) Evaluate the appropriateness of this approach.

**10.** (*7 points*) Paisley Company plans to enter the blockchain insurance market. Paisley has hired recent software engineering graduates to build the framework. The following utility curve measures the performance of engineers A, B, C and D.




(a) (*1 point*) Rank the performance of engineers A, B, C and D, according to the curve. Justify your response.

Paisley is seeking other high-quality software engineering graduates and has identified that work performance is correlated to the student's grade point average (GPA). The table below lists the GPAs of five current engineers at Paisley who meet its standard.

| **Engineer** | **GPA (out of 5)** |
|---|---|
| E | 4.5 |
| F | 4.8 |
| G | 4.7 |
| H | 4.6 |
| I | 4.8 |

## 10. Continued

Paisley needs to be at least 95% confident that a candidate can perform up to the company standard to grant an interview.

(b) (*2 points*) Estimate the minimum GPA for a candidate to receive an interview.

(i) Using the "mathless approach." State your reasoning.

(ii) Using statistical methods. Show your work.

Paisley's HR area has received 100 resumes that satisfy the minimum GPA requirement. Software engineering graduates are in high demand and typically have multiple job offers. The development department is looking to add one new hire before the end of the month.

(c) (*1 point*)

(i) Explain whether 10 interviews is the optimal strategy to find the best candidate.

(ii) Explain whether 50 interviews is the optimal strategy to find the best candidate.

There exists a popular third-party test taken by most software engineers. Paisley thinks test performance is good enough to provide managers with full information to make hiring decisions.

Paisley would like a new hire to start before the end of the month but has some flexibility to extend the start date one month.

(d) (*2 points*) Develop a strategy for Paisley to find the new hire using the test performance and the start date criteria.

Last year, Paisley's leadership suggested that all employees meet with their managers monthly to discuss personal development.

(e) (*1 point*) Develop a method for Paisley's leadership to estimate the percentage of employees who discussed personal development with their managers last month.

**11.** (*10 points*) Future Mining (FM) plans to extract platinum from asteroids. FM has identified an asteroid which it believes contains platinum that can be extracted for a cost of $1 billion. However, investors are skeptical of the amount of platinum that could be brought back to Earth.

(a) (*2 points*) Outline an Applied Information Economics (AIE) framework to address the investors' concerns.

Some FM analysts are using a Bayesian approach to estimate the amount of platinum that can be harvested and brought back to Earth. One statistician complains that this approach is subjective.

(b) (*1 point*) Assess the validity of the statistician's complaint.

Research shows that asteroids may contain platinum on or beneath the surface. FM's satellite imaging detected no platinum on the asteroid's surface.

FM's CEO states, "The fact we can't see any platinum tells us nothing. We're moving ahead with our plan to send a rocket to that rock."

(c) (*1 point*) Critique the CEO's statement.

The CFO persuades the CEO to build a probe to collect samples below the asteroid's surface at different depths. The probe can only collect ten samples.

(d) (*2 points*) Design an approach to estimate how platinum deposits may be distributed below the asteroid's surface.

To develop the probe, FM's engineers need to consider the following three necessary projects that can only be worked on one at a time.

| Project | Development Period | Cost | Probability of Success |
|---|---|---|---|
| A: Sample collection apparatus | 6 months | $20M | 80% |
| B: Landing gear | 12 months | $50M | 30% |
| C: Probe shell material | 18 months | $100M | 50% |

## 11. Continued

The risk-free interest rate is 10% and FM's cost of capital is 15%. Costs are incurred at the start of each project.

(e) (*2 points*)

(i) Determine the optimal order of development for these three projects. Show your work.

(ii) Calculate the NPV of the probe project given the order determined in (i).

Assume the probe can provide a perfect analysis of the asteroid's distribution of platinum. There is a 10% chance that the asteroid has platinum and will provide a present value of revenue of $8 billion, regardless of when the extraction begins. If the probe development project fails, FM's investors will not allow the company to move forward with extraction.

(f) (*2 points*)

(i) Identify the real option embedded in developing the probe.

(ii) Assess if FM should develop the probe or should attempt to extract immediately without first sending the probe.

**12.** (*7 points*) Swift LTD is a large company specializing in women's clothing. Swift has more than $500M of unencumbered assets, mainly equipment, inventory and real estate. You are given Swift's current operating information:

| | |
|---|---|
| Debt to Equity Ratio | 1.0 |
| Equity Cost of Capital | 10% |
| Debt Cost of Capital | 6% |
| Corporate Tax Rate | 40% |

Swift is considering two expansion proposals.

Proposal A: Development of a new men's line of clothing

| | |
|---|---|
| Upfront costs | $4M |
| Initial investment in equipment | $12M |
| Expected incremental earnings before interest & tax | $20M per year for 3 years |
| Expected equipment life | 3 years |
| Equipment depreciation method | Straight-line |
| Salvage value of the equipment | $0 |

Proposal B: Acquisition of another firm that specializes in men's clothing

| | |
|---|---|
| Purchase price of firm | $100M |
| Amount of purchase price financed by debt | $60M |
| Expected increase in free cash flow in the first year | $4.56M |
| Expected annual growth rate of the increase in free cash flow for future years | 3% |

Assume the following:

- Swift is in a growth phase and has limited capital.
- Swift plans to maintain the same debt-equity ratio.
- Each proposal has a similar risk profile to that of Swift.

(a) (*2 points*)

(i) Calculate the NPV of Proposal A using the weighted average cost of capital (WACC) method. Show your work.

(ii) Calculate the NPV of Proposal B using the adjusted present value (APV) method. Show your work.

(iii) Recommend which proposal Swift should accept. Justify your recommendation.

## 12. Continued

(b) (*1 point*) Evaluate the appropriateness of using WACC as the discount rate for capital budgeting decisions.

(c) (*2 points*)

(i) Describe a method to calculate the shareholders' gain from the expansion based on the cash flow shareholders will receive.

(ii) Explain how this method impacts Swift's choice between Proposal A and Proposal B.

Swift decides to proceed with Proposal B and needs to raise capital.

(d) (*1 point*) Recommend which type of commercial bank loan is most suitable. Justify your recommendation.

(e) (*1 point*) Recommend one strategy, other than raising equity or debt capital, that Swift can use to expand into men's clothing. Justify your recommendation.

****END OF EXAMINATION****
**Afternoon Session**

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