SOCIETY OF ACTUARIES
Foundations in CFE Exam

Exam CFEFD

MORNING SESSION

Date: Wednesday, April 30, 2014
Time: 8:30 a.m. – 11:45 a.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This examination has a total of 100 points. It consists of a morning session (worth 60 points) and an afternoon session (worth 40 points).

   a) The morning session consists of 9 questions numbered 1 through 9.

   b) The afternoon session consists of 5 questions numbered 10 through 14.

   The points for each question are indicated at the beginning of the question. There are no questions in the Morning Session that 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.

Tournez le cahier d'examen pour la version française.

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Exam CFEFD-Front Cover

****BEGINNING OF EXAMINATION****
Morning Session

1. (*6 points*) Alarka Insurance recently began issuing a variable annuity with a guaranteed minimum withdrawal benefit. Alarka uses the Black-Scholes lognormal model to value the guarantee. The CRO has concerns about model risk.

(a) (*3 points*) Describe four reasons why using the Black-Scholes lognormal model to value the guarantee is inappropriate.

The CRO mandates that Alarka change to Monte Carlo simulation with a regime-switching lognormal model to value the guarantee.

(b) (*2 points*) Describe four model risks, specific to valuing the guarantee, which remain even when an appropriate model is used.

(c) (*1 point*) List four ways to protect against model risk.

2. (*7 points*) Big Bradley Bank just wrote one unit of each of the following at-the-money equity options on the same stock:

- Option A: conventional European put option
- Option B: Asian arithmetic price (annual average) put option

Assume the price of the stock underlying both options follows a geometric Brownian motion process. Option A and option B also share the following characteristics:

Time Horizon	2 years
Stock Price at Time 0	100
Risk-Free Rate	1%
Risk Premium	9%
Annual Volatility of Stock Price	20%

Big Bradley is measuring the VaR(95%) of the payoff at maturity for both options.

You are given the following values from the cumulative normal distribution:

x	-1.64	-1.28	-0.84	-0.52	-0.25
$\Phi(x)$	0.05	0.10	0.20	0.30	0.40

(a) (*2 points*) Calculate, analytically, the VaR(95%) of the payoff at maturity for Option A, given an expected payoff of 4.38. Show your work.

Big Bradley ran 1,000 simulations on the price of the underlying stock index using the Euler scheme $\left(S_{k+1} = S_k + \mu \cdot S_k \cdot \Delta t + \sigma \cdot S_k \cdot \Delta W_k\right)$ with an annual step. Simulation #153 generated the VaR(95%) of the payoff at maturity for both options:

	Standard Normal Random Number	
Simulation	Step 1	Step 2
#153	-1.50	-0.75

(b) (*1 point*) Calculate the simulated VaR(95%) of the payoff at maturity for Option A, assuming the simulated expected payoff for Option A is 3.99. Show your work.

2. **Continued**

(c) (*1 point*) Calculate the simulated VaR(95%) of the payoff at maturity for Option B, assuming the simulated expected payoff for Option B is 3.38. Show your work.

(d) (*2 points*) Apply the control variate technique to improve the VaR(95%) of the payoff at maturity for Option B, using the results above. Show your work.

(e) (*1 point*) Evaluate whether using a control variate is appropriate in this situation.

3. (*7 points*) Five years ago, you founded Cascades, a private internet startup company. So far your company has gone through three funding rounds.

Round	Investor	Shares	Share Price ($)
Series A	You	1,000,000	1.00
Series B	Angel Investors	2,000,000	4.00
Series C	Venture Capital	2,000,000	9.00

You would like to raise an additional $80 million in capital and are considering an initial public offering (IPO). An investment banker, Jessica, would underwrite your IPO, guaranteeing all shares will be sold, for an underwriting fee of 7% of the IPO price. She recommends issuing 5,000,000 new shares at an IPO share price of $16.

(a) (*1 point*) Describe three ways an underwriter can take a firm public through an IPO.

Your CFO thinks that Jessica's $16 IPO share price is too low. He predicts that the share price will double to $32 on the first day of trading.

(b) (*1 point*) Assuming the CFO is correct:

(i) Calculate the impact to the underwriter. Show your work.

(ii) Calculate the impact to the IPO investors. Show your work.

(c) (*1 point*) Calculate the pre-IPO fair market value per share, assuming the CFO is correct. Show your work.

(d) (*1 point*) Explain why the existing investors may still desire the IPO despite the potentially high cost.

You consult another investment banker, Nick, who recommends delaying the IPO. He suggests that you raise $80 million through a bond issuance.

(e) (*1 point*) Describe how each of the following would impact the price of the individual bonds:

(i) Higher call price, for a callable bond

(ii) Higher conversion ratio, for a convertible bond

(iii) Bond covenants

3. Continued

(f) (*1 point*) Identify, in general, two advantages and two disadvantages of a debt issuance as compared to an IPO.

(g) (*1 point*) Recommend whether to take Jessica's or Nick's recommendation, from the perspective of each of the following. Justify your recommendation.

(i) Angel Investors

(ii) CFO, who does not own any shares

4. (*6 points*) You live in Atiaga, whose currency is the Atiaga dollar (A$). Kasoa is a neighboring country, whose currency is the Kasoa dollar (K$). You would like to analyze a K$-denominated index, *U*, on the Kasoa Stock Exchange.

You model the equity and foreign exchange separately using the stochastic process *X*, satisfying the stochastic differential equation:

$$dX(t) = X(t)\left(\mu_X\, dt + \sigma_X\, dW(t)\right)$$

where $X(t)$ is the value of the process at time *t*, μ_X and σ_X are constants, and $W(t)$ is a standard Wiener process.

(a) (*2 points*) Show, by applying Ito's Lemma for $d(\ln X)$, that the solution of the equation above is:

$$X(T) = X(0)\exp\left[\left(\mu_X - \tfrac{1}{2}\sigma_X^2\right)T + \sigma_X\sqrt{T}Z\right]$$

where $T > 0$ and $Z \sim N(0,1)$.

Let *f* represent the A$/K$ exchange rate (representing the amount of A$ per K$), and assume *U* (in K$) and *f* are driven by two correlated Brownian motions respectively:

$$dU(t) = U(t)\left(\mu_u\, dt + \sigma_u\sqrt{dt}\, Z_U(t)\right)$$
$$df(t) = f(t)\left(\mu_f\, dt + \sigma_f\sqrt{dt}\, Z_f(t)\right)$$

where Z_U and Z_f are standard normal variates with correlation ρ.

(b) (*1 point*) Describe how to generate the correlated random variates Z_U and Z_f from independently generated standard normal variates Z_1 and Z_2.

(c) (*3 points*) Given a portfolio P where 200 A$ is invested in the K$-denominated index *U* at time 0 with the starting exchange rate $f(0) = 2$ A$ / K$:

(i) Determine, at time 0, the value of P in terms of K$.

(ii) Determine, at time *T*, the expression for P in terms of K$.

(iii) Determine, at time *T*, the expression for *f* in terms of A$/K$.

(iv) Determine, at time *T*, the expression for P in terms of A$.

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5. (*8 points*) Maidenhair, a public company, is domiciled in the U.S. with no corporate debt outstanding. It has reported positive earnings to date.

You have the following financial data available:

Shares outstanding	50 million
Price per share	$20
Equity cost of capital	15%
Corporate tax rate	35%

Maidenhair is considering issuing $500 million of 6% corporate bonds and maintaining the same amount of debt permanently. Assume taxes are the only market imperfection.

(a) (*1 point*) Explain how leverage would change the value of Maidenhair.

(b) (*3 points*) Complete the market value balance sheet below. Show your work.

	Before $500M Bond Issue	**After $500M Bond Issue**
Cash from bond issue	$0M	$500M
Original assets	$1000M	
Tax shield		
Total assets		
Debt	$0M	
Total liabilities	$0M	
Equity		
Fair price per share	$20	
Cost of capital		

5. Continued

You are considering how best to return the $500 million of bond proceeds to shareholders. Assume Maidenhair's shareholders are subject to a 30% tax rate on dividends and a 15% tax rate on realized capital gains.

(c) (*4 points*)

(i) Calculate the average benefit per share if the bond proceeds are used to pay a one-time special dividend. Show your work.

(ii) Calculate the average benefit per share if the bond proceeds are used to repurchase shares. Show your work.

(iii) Identify shareholder behavior considerations that affect the choice of paying a one-time special dividend or repurchasing shares.

(iv) Recommend whether Maidenhair should pay a one-time special dividend or repurchase shares in order to maximize shareholder value. Justify your recommendation.

6. (*6 points*) On May 31, 2014, Hen Wallow Group and Glencannon Financial may enter a forward starting swap with one another on the following terms:

Notional	$10 million
Term	3 years
Start Date	In 1 year
Payment Frequency	Annual
Payment Timing	End of year
Fixed Rate Payer	Glencannon
Fixed Rate	8.00%
Floating Rate Payer	Hen Wallow
Floating Rate	LIBOR + 0 bps

(a) (*1 point*) Determine the cash flows each party would receive (+) or pay (−) each year by completing the table below for the given LIBOR projection:

As of May 31,	**2014**	**2015**	**2016**	**2017**	**2018**
LIBOR	8.00%	7.50%	6.00%	9.00%	8.50%
Hen Wallow Cash Flows					
Glencannon Cash Flows					

Instead of the forward starting swap, Hen Wallow purchases a swaption from Glencannon that expires in 1 year.

(b) (*1 point*) Define swaption.

Hen Wallow uses the Black model to value the swaption, where:

$$d_1 = \frac{\left(\ln\left(\frac{R_F}{R_X}\right) + \frac{\sigma^2 T}{2}\right)}{\sigma\sqrt{T}}$$

$$d_2 = d_1 - \sigma\sqrt{T}$$

$$X = L \bullet A\left[R_F\ N\left(d_1\right) - R_X\ N\left(d_2\right)\right]$$

6. Continued

(c) (*2 points*) Complete the following table for the swaption, including definitions and values, based on the Black model:

Item	Definition	Value
R_F	(i)	7%
R_X	Strike rate of underlying swap	(ii)
σ	(iii)	25%
T	(iv)	(v)
L	Notional value of swap	(vi)
A	(vii)	2.86
X	(viii)	\$142,000

On May 30, 2015, one day before expiry, the swaption is in the money, and Hen Wallow is deciding whether to exercise the swaption or cash it out and replicate the swap cash flows using over-the-counter bond derivatives. Hen Wallow's chief actuary is concerned with improving liquidity, while its CFO is focused on minimizing capital and counterparty risk, including recent regulatory changes from Dodd-Frank legislation.

(d) (*2 points*) Recommend, from the perspective of each of the following, whether Hen Wallow should exercise the swaption or replicate the swap cash flows using bond derivatives. Justify your recommendation.

(i) Chief actuary

(ii) CFO

7. (*6 points*) You are calculating the VaR for a commodities portfolio.

(a) (*2 points*) List four advantages and four disadvantages of using non-parametric models for calculating VaR.

Your colleague has suggested a basic historical simulation approach, determining VaR from the empirical distribution.

(b) (*1 point*) Describe two issues with using a long sample period for the historical simulation.

The model validation team is concerned about the volatility of the VaR estimate as extreme outcomes move out of the sample period.

(c) (*1 point*) Recommend a modification that will alleviate their concerns. Justify your recommendation.

The model validation team is also concerned that the current approach does not respond enough to changes in market volatility.

(d) (*1 point*) Explain how volatility-weighted historical simulation could improve sensitivity to changes between stable and more volatile market conditions.

Your boss wants to understand the potential uncertainty in the point estimate of VaR.

(e) (*1 point*) Recommend an approach for calculating the confidence interval for VaR. Justify your recommendation.

8. (*8 points*) Rainbow Falls, a small insurance company, sells a long-term care product with extremely low assumed lapse rates. Rainbow Falls is valuing the associated interest rate risk of the following long-term liability cash flows:

Year	30	35	40	45
Liabilities	100,000	300,000	500,000	100,000

The 30-year zero-coupon continuous spot rate is 3.9%.

(a) (*2 points*) Calculate the present value of the liability cash flows using a simple monopole assuming a continuous forward rate of 4.0% for all durations greater than 30. Show your work.

Rainbow Falls is also considering a static control model.

(b) (*2 points*) Describe the standard static control model.

(c) (*2 points*) Calculate the implied forward rate for the static control model, assuming the total return vehicle is a standard normal process with an expected return of 7% and volatility of 16%. Show your work.

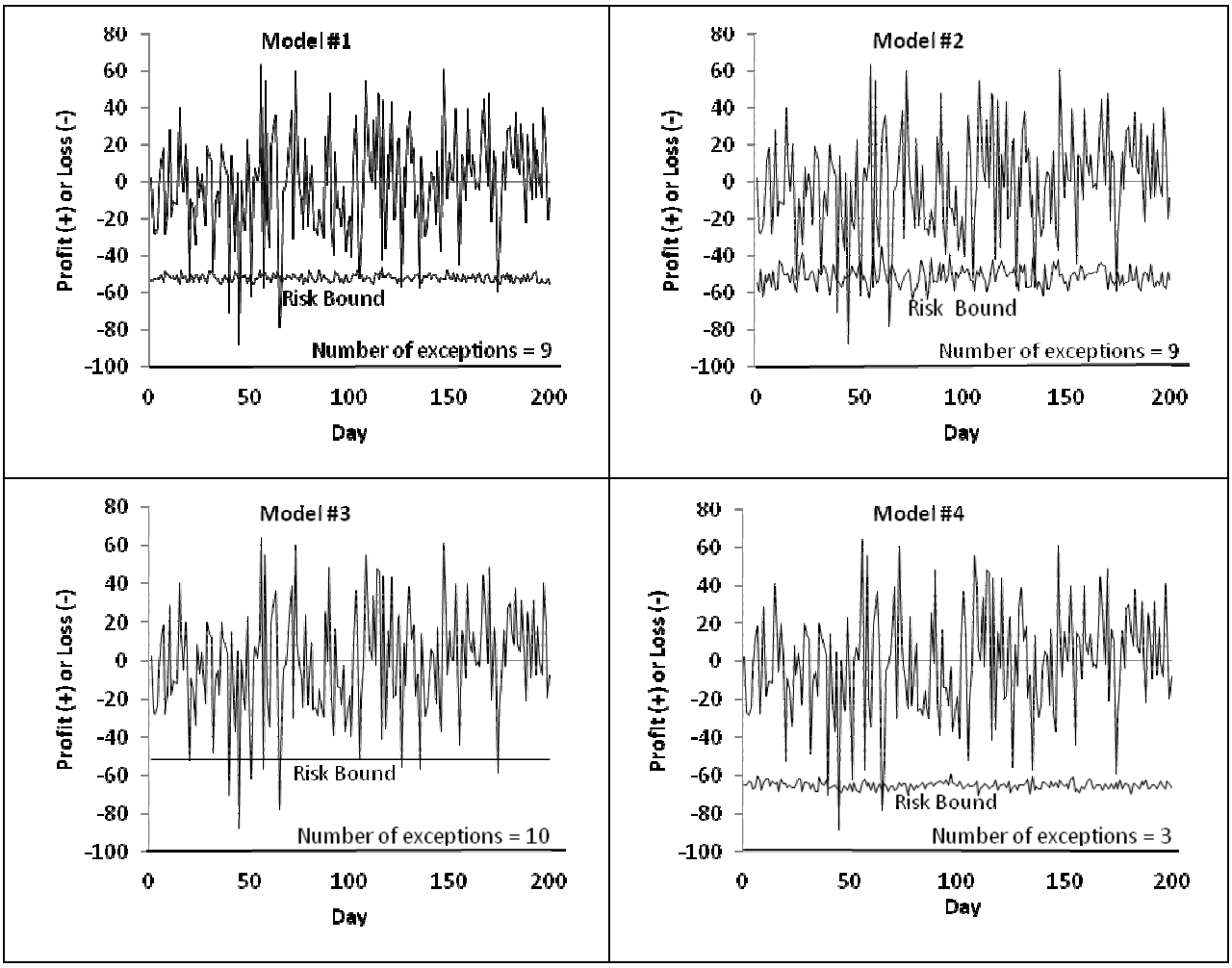
(d) (*2 points*)

(i) Describe the advantages of a simple monopole.

(ii) Describe the advantages of a static control model.

(iii) Recommend whether Rainbow Falls should use a simple monopole or the static control model. Justify your recommendation.

9. (*6 points*) You are a risk manager at Roaring Fork Bank. Roaring Fork has developed four models to forecast daily Value at Risk (VaR). Your staff has recently completed backtesting analysis on the four models and provided you the following backtesting charts:



9. Continued

You are given the following values for a cumulative binomial distribution:

x	n	p	$F(x)$
3	200	0.05	0.0090
4	200	0.05	0.0264
5	200	0.05	0.0623
14	200	0.05	0.9219
15	200	0.05	0.9556
16	200	0.05	0.9762

(a) (*2 points*) Determine for each model, whether it passes the basic frequency backtest (Kupiec) assuming a 95% confidence level and a two-sided alternative hypothesis. Show your work.

(b) (*2 points*) Evaluate each of the four models as a good, medium, or poor fit, using both visual inspection and the results from part (a). Support each evaluation.

(c) (*2 points*) Recommend two improvements to the backtesting analysis. Justify your recommendations.

****END OF EXAMINATION****
Morning Session

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