SOCIETY OF ACTUARIES
Quantitative Finance and Investment Core

Exam QFICORE

AFTERNOON SESSION

Date: Tuesday, October 28, 2014
Time: 1:30 p.m. – 3:45 p.m.

INSTRUCTIONS TO CANDIDATES

General Instructions

1. This afternoon session consists of 6 questions <u>numbered 10 through 15</u> for a total of 40 points. The points for each question are indicated at the beginning of the question.

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. When you are asked to recommend, provide proper justification supporting your recommendation.

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 QFICORE.

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.

10. (*4 points*) Bob buys an at-the-money 2-year call option on one stock today and self-finances it by shorting the underlying stock and borrowing or lending at the risk-free rate. He then delta-hedges his portfolio once a year. The annualized risk-free rate is 1% continuously compounded, the stock pays no dividend and the implied volatility is constant at 25% annually.

(a) (*3 points*) Complete the table below. Show your calculations.

Time (Years)	Under-lying Stock Value	Option Value / Payoff (A)	Option Delta	Number of Shares Held	Value of Shares (B)	Cash / (Borrowing) (C)	Portfolio Value (A+B+C)
0	100	14.9					0
1 prior to rebalancing	115	20.5					
1 post rebalancing	115	20.5					
2	105	5	1				

Bob expected that his ending portfolio value would be zero.

(b) (*1 point*) Explain why Bob's final portfolio value did not turn out to be close to 0.

11. (*9 points*) ABC insurance company has a block of equity-linked index universal life (EIUL) insurance policies which credit policyholder interest based on the point-to-point annual return of the S&P 500 index (SP).

The annual interest credited to policyholders is capped at 15% and floored at 0%.

You are given the following under risk neutral valuation:

	EIUL Liability ($millions)		
	SP Vol = 19%	SP Vol = 20%	SP Vol = 21%
SP decrease 1%	64.1	64.8	65.4
SP = 1,700	67.7	68.2	68.7
SP increase 1%	71.3	71.7	72.0

(a)   (*2 points*) Define and estimate the following Greeks for the EIUL benefit:

(i)   Delta

(ii)   Gamma

(iii)   Vega

Assume the following:

- Risk-free interest rate = 5% per annum continuously compounded

- SP dividend yield = 3% per annum continuously compounded

- The current SP level is 1,700

- The multiplier for option contracts on SP is $100 (that is, the value of each contract is equal to the current index level × $100)

- Time to maturity of options on SP = 1 year

- Constant SP volatility = 20% per annum

- There are 250 trading days in a year

(b)   (*1 point*) Explain how you can construct a static hedge for the crediting strategy of the EIUL policy using a bull call spread, assuming zero-coupon bond investment will provide the minimum crediting interest.

11. **Continued**

    (c)   (*2 points*) Calculate using Black-Scholes-Merton model, the number(s) of SP call options needed to implement the hedge in part (b).

    (d)   (*1.5 points*) Calculate the initial cost of setting up the hedge portfolio in (b).

Now assume there is another block of EIUL insurance policies which also credit policyholder interest based on the return on the S&P 500 index, but without any caps or floors. You have just set up a delta-neutral hedge program for this block by going long 1,000 At-The-Money (ATM) one-year SP call options.

    (e)   (*1.5 points*) Calculate the Gamma and Theta of the 1,000 long ATM call options on the day they were established.

Immediately after the hedging position has been set up, the SP level drops to 1,698.

    (f)   (*1 point*) Estimate, using the Gamma and Theta, the gain or loss on the 1,000 long ATM calls on the next trading day.

12. (*7 points*) You are a portfolio manager for Evergreen, a large fixed income fund.

You consider an inverse floater that is linked to the 6-month LIBOR. The inverse floater has the following characteristics:

Notional	$10,000,000
Market Value	$9,500,000
Coupon	Semi-annual
Maturity	10-year
Fixed Reference (K)	10%
Coupon Leverage (L)	1.0
Cap	No
Floor	No

(a)   (*1 point*) Calculate cash flows of the inverse floater given the following projected 6-month LIBOR.

Six-month LIBOR	Cash Flow of Inverse Floater (per $100 notional)
2%	
12%	

(b)   (*2 points*)

(i)   Explain how the cash flows of the inverse floater may be replicated using the trading strategy involving a bond and a floater.

(ii)   Calculate the duration of the inverse floater, given the following estimates:

| Duration (6-month LIBOR) | 0.5 |
| Duration (10-year 5% Treasury Bonds) | 6.0 |

12. Continued

Anticipating a rise in interest rates, you want to remove the interest rate risk on the inverse floater using a delta hedge strategy and U.S. Treasury futures.

Treasury futures price	$100,000
Duration of Treasury futures	8.5
Conversion factor (cheapest-to-deliver)	1.2

(c)   (*2 points*)

    (i)   Determine whether you need to buy <u>or</u> sell futures contracts.

    (ii)   Estimate how many futures contracts would be needed to achieve your objective. Justify your answer.

To invest a cash portfolio in the money market, you consider entering into a repurchase agreement with Godman, an AA-rated investment bank, where Godman will agree to deliver $1,007,500.50 worth of 10-year Treasury notes to you and after 30 days, will buy back the same 10-year notes for a price of $1,008,214.15.

Given the following market rates:

| Fed Fund Rate | 25 bps |
| Four-week Treasury bill | 50 bps |

(d)   (*1 point*) Calculate the repo rate.

(e)   (*1 point*) List two benefits for each party to enter into this repurchase agreement.

13. (*8 points*) You are a portfolio manager for a large pension plan that currently has $100 million assets under management and is well diversified.

You recently read the following statement in a research report on portfolio management:

"The Sharpe ratio measures a portfolio's excess return to its total risk; it answers the question of how much a portfolio manager is compensated for taking risk. Because it typically uses a passive benchmark chosen by the portfolio manager based on their investment styles, the higher the Sharpe ratio, the better the manager's performance. Therefore, the Sharpe ratio is best used as a measurement of manager skills."

(a) (*1.5 points*) Assess the correctness of each of the three comments in the above statement.

(b) (*1.5 points*) Draft a corrected version of the above statement.

Suppose that you can hire a small cap long-only manager who can generate a 5% alpha return from his stock selection. To fund this small cap manager, you plan to sell $10 million of your current large cap holdings.

The large cap and small cap capitalization sectors are represented by the S&P 500 and Russell 2000 indices, respectively.

Assume that there are no margin account and interest requirements.

(c) (*1.5 points*) Design a portable alpha strategy that can maintain the current strategic asset allocation and enhance performance by adding small cap alpha. List your implementation steps.

(d) (*1.5 points*) Illustrate the portable alpha strategy that you proposed above by showing its annual returns under the following market scenarios, assuming that the small cap manager generates the expected alpha:

- Up market: S&P 500 up 10% and Russell 2000 up 15%.

- Down market: S&P 500 down 10% and Russell 2000 down 15%.

13. **Continued**

You want to adopt the following asset allocation strategy to outperform the broad market:

Investment	Allocation Percentage
S&P 500 Index Fund	70%
Actively Managed U.S. Small Cap Fund	15%
Actively Managed U.S. Growth Fund	15%

(e)   (*0.5 points*) Identify the asset allocation strategy.

(f)   (*1 point*) Compare and contrast this asset allocation strategy to:

- Strategy I: 100% allocated to S&P 500 Index Fund.

- Strategy A: 100% allocated to US Growth Fund.

Your assistant suggests an alternative allocation strategy as follows:

Investment	Allocation Percentage
S&P 500 Index Fund	70%
U.S. Small Cap Fund ETF	15%
U.S. Growth Fund ETF	15%

(g)   (*0.5 points*) Assess this suggestion.

14. (*6 points*) Brian Fantana is a pension fund manager at CatharSys, a small technology startup firm and has contracted you as an actuarial consultant to help brainstorm asset allocation strategies for its defined benefit pension plan.

The plan has the following characteristics:

- The average employee's age is 35 years old.

- The employees are accumulation-focused and risk-tolerant.

- The company has had much commercial success and is planning to aggressively grow its staff over the next 5 years with young talent.

- Due to the recent market downturn, the fund is currently slightly underfunded.

- Interest rates have remained low for an extended period of time.

You recommend that Brian look into using an ALM approach to asset allocation. You introduce the following dimensions of the ALM approaches:

- Risk level (low to high)

- Time period (static or dynamic)

(a) (*2 points*) Describe the ALM approaches under each of the above listed dimensions.

(b) (*2 points*) Recommend the ALM approach for the pension fund by considering each dimension.

Brian presented the findings to CFO of CatharSys. CFO's response to the choice of using an ALM approach was as follows:

> *"We're looking at young technopreneurs who are savvy in investments. Look, I'm 40 years old – why should I have low-spread fixed income securities backing my pension? Talk to the consultant about using a more asset-driven approach and show me a high Sharpe ratio on our pension fund investments."*

Brian reaches out to you for help in responding to CFO's statements.

(c) (*2 points*) Assess the validity of CFO's statements.

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15. (*6 points*) You are an investment manager for a large mutual life insurance company, ABC Life. The company sells a wide variety of both life insurance and annuity products.

(a) (*2 points*) Explain the characteristics and concerns for strategic asset allocation, as they relate to life insurance companies.

ABC's universal life investment portfolio has the following investment goals:

- Return objective: The return objective is to maximize return.

- Risk objective: Senior management has set a limit that the standard deviation of portfolio returns on all portfolios should not exceed 8.0% annually.

You are given a set of corner portfolios.

| | | | Asset Class (Portfolio Weight) | | | | |
Portfolio Number	Expected Return	Standard Deviation	Real Estate	Private Placement Bonds	Short Term Bonds	Public Medium Term Bonds	Long Term Bonds
1	10.00%	15.00%	100.00%	0.00%	0.00%	0.00%	0.00%
2	8.86%	11.04%	61.90%	0.00%	0.00%	0.00%	38.10%
3	8.35%	9.80%	40.31%	13.85%	0.00%	0.00%	45.83%
4	7.94%	8.99%	32.53%	14.30%	0.00%	8.74%	44.44%
5	7.30%	7.82%	19.93%	21.09%	16.85%	0.00%	42.13%
6	6.13%	5.94%	0.00%	26.61%	37.81%	0.00%	35.58%
7	5.33%	5.37%	0.00%	13.01%	59.94%	0.00%	27.06%
Average Duration			10.3	6.4	1.9	5.2	11.4

(b) (*2 points*) Propose an asset allocation strategy for ABC Life's universal life insurance portfolio. Show your work.

15. Continued

Interest rates have been declining for many years. ABC Life has a large inforce block of universal life policies that it credits interest on, based on investment income from the underlying asset portfolio. ABC's Chief Risk Officer (CRO) is concerned about interest rates rising sharply. In this spike scenario, he believes that many of these policyholders would chase the higher interest rates by surrendering their policies. Surrender benefits would then have to be paid to the policyholders from the underlying asset portfolio. An actuary on the CRO's modeling team has calculated the duration of these liabilities as 6.5.

(c)   (*1 point*) Describe your concerns with the portfolio you proposed in part (b).

(d)   (*1 point*) Propose changes to your allocation strategy in part (b) to address the CRO's concerns. Justify your answer.

END OF EXAMINATION
Afternoon Session

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