November 2000
Course 8V

Society of Actuaries

Questions 1 – 3 pertain to the Case Study.

Each question should be answered independently.

1. *(10 points)* The Board of Directors of LifeCo was recently given a presentation on the paper by Robert van der Meer and Meye Smink, Strategies and Techniques for Asset-Liability Management: An Overview. As the newly appointed Chief Risk Officer for LifeCo, the Board has asked you to give a presentation.

(a) Categorize and describe the ALM strategies and techniques employed by LifeCo within the framework provided by van der Meer and Smink.

(b) Assess the relative merits or return-driven versus value-driven strategies for LifeCo.

(c) Formulate an ALM strategy for LifeCo (from the framework provided by van der Meer and Smink) that reduces the total company exposure to interest rate risk and provides an opportunity to increase company surplus.

(d) Evaluate your proposed strategy using the criteria set out in the paper by van der Meer and Smink.

2. *(9 points)* LifeCo management wants to segment the Group line of business for asset/liability management purposes into:

        (i)   Long Term Disability (LTD), and
        (ii)   Other A&H.

The newly allocated balance sheet for LTD is shown below:

	Present Value	Modified Duration	Adjusted Duration
Assets	550.9	13.5	11.00
Liabilities	532.0	8.1	5.37
Economic Value	18.9		169.47

The Relative Volatility of assets for Other A&H is the same as for LTD. The Relative Volatility of liabilities for Other A&H is 1.

(a)   Construct the new Other A&H allocated balance sheet.

(b)   Assess the limitations of only using the above measures in managing interest rate risk.

(c)   Contrast the use of Adjusted Duration with the measures used by LifeCo to manage its exposure to interest rate risk.

(d)   The portfolio manager for the Group line of business argues that Franchise Value should be considered in the liability target duration calculation. Define Franchise Value.

(e)   Explain the implications of using Franchise Value for determining target durations.

3. *(22 points)* LifeCo wants to establish a delta/gamma/vega/rho hedge on the equity exposure of their variable annuity business, using positions in some or all of the following assets.

Asset	Price	Delta	Gamma	Vega	Rho
S&P 500 Future	0	100	0	0	0
30-year Treasury bond future	0	0	0	0	-12,598
1-year Put	51.98	-0.34608	0.00184	3.688	-3.98
1-year Call	109.45	0.65392	0.00184	3.688	5.45
10-year Put	42.88	-0.10529	0.00029	5.761	-14.82
10-year Call	489.57	0.89472	0.00029	5.761	40.51

LifeCo's liabilities have the following sensitivities:

Delta	– 2,659.90
Gamma	1.036
Vega	1952
Rho	– 101,910,000

All deltas and gammas are per unit change in the S&P 500 index.
Vegas are per 1% change in volatility
Rhos are per 1% change in interest rates
Current value of the S&P 500 is 1300

(a) *(6 points)* Construct a hedge position using the above assets that minimizes the cost of the hedge without regard to the operational guidelines.

(b) *(1 point)*

    (i) Assess whether the hedge determined in part (a) would be in violation of the operational guidelines for use of derivatives.

    (ii) Recommend any necessary changes to the guidelines.

3. **(Continued)**

    (c)   *(6 points)*

        (i)   Calculate the 1-day, 99%VAR on the portfolio, before and after the hedge is applied using delta and gamma to approximate it.

        (ii)   Assess the validity of these numbers.

    (d)   *(4 points)* LifeCo is worried about the liquidity of the 30-year Treasury bond future.

        (i)   Analyse the effectiveness of the proposed hedges with respect to rho.

        (ii)   Propose alternative methods and alternative assets to improve rho exposure coverage.

    (e)   *(5 points)* The newly appointed Chief Risk Officer is concerned about the use of derivatives in the hedging strategy. Verify that the operational and credit risks of managing derivatives have been adequately covered by LifeCo's operational guidelines for use of derivatives.

4. *(6 points)* You have the following market information:

- Price of a 2-year zero coupon bond: 89
- 1-year short rate (i_0): 7%

A new actuarial student in your company has implemented an interest rate model to price interest rate derivatives. His model gives the following results:

Sample space	i_1
w_1	6.0%
w_2	8.0%

(a) Describe the different types of model risk that must be considered when building or using a model.

(b) Explain the concept of arbitrage-free in the context of an interest rate model for pricing derivatives.

(c) Assess the validity of the proposed model given the information above.

5. *(4 points)*

(a) Describe how the following factors will generally impact the Option-Adjusted Spread (OAS) of a Planned Amortization Class (PAC) for a typical PAC bond.

    (i) Average life of the PAC
    (ii) Premium versus discount collateral
    (iii) Lockout versus no lockout
    (iv) Window length
    (v) Whether or not a Z-bond funds the PAC

(b) Describe the shortcomings associated with OAS in evaluating mortgage-backed securities.

(c) Describe how you would use OAS, considering the shortcomings.

6. *(5 points)* You are given the following information on a European put option on a bond:

- Put option
    - Maturity of option   1 year
    - Strike price level   1000

- Underlying bond
    - Cash price   1000
    - Present value of bond coupon payments   100
    - 1 year forward yield volatility   10%
    - Modified duration   10 years
    - Forward yield   7%

- Risk-free rates are flat at 5.13%

(a)   Calculate the price of this option using Black's model. Show your work.

(b)   Contrast alternatives for calculating delta and gamma for this option with a stock option.

7.   *(4 points)*

(a)   Describe the psychological factors that prevent rational investment decision-making.

(b)   List five major anomalies which the standard paradigm of rationality fails to explain. Give an example for each case and specify the key behavioral factors that explain such anomalies.

** END OF EXAMININATION **
MORNING SESSION

8. *(4 points)* As a product development actuary you have been asked to research and develop an Equity Indexed Annuity (EIA) product.

(a) Describe the basic product features of an EIA.

(b) Recommend and justify an investment strategy for the EIA product.

(c) Describe the potential risks associated with an EIA and the investment strategy you have recommended in (b).

9. *(7 points)* Consider a simple sequential Commercial Mortgage-Backed Securities (CMBS) deal with the following senior/subordinated structure:

Class	Rating	Average Life	Size
A-1	AAA	9.3	73.50
A-2	AA	10.0	5.50
A-3	A	10.0	6.00
B-1	BBB	10.0	4.75
B-2	BB	10.0	4.00
B-3	B	10.0	4.00
C	Not Rated	10.0	2.25
Loan	N/A	9.5	100.00

Collateral information:

	Debt Service Coverage Ratio (DSCR)	Loan-to-value (LTV)	Net Operating Income (NOI) Volatility
Original	2.5	65%	6%
Stressed	1.2	90%	10%

- Collateral consists of 9% coupon, non-callable, 10-year balloon, commercial mortgage loans with a 30-year amortization schedule.

- Subordinated class loss allocation: C, B-3, B-2, B-1, A-3, A-2.

(a) Describe how your Option Adjusted Spread (OAS) valuations would change by rated class if the collateral weighted average DSCR and LTV ratios were to change over the short term from original to stressed levels.

(b) Describe the relative impact of using the stressed NOI volatility assumption versus the original assumption on your OAS valuations for the B classes.

9. **(Continued)**

    (c)   Assume the following:

- The collateral is made up of lower quality commercial mortgage loans that have prepayment penalties and are fully callable at par after five years without penalty.

- The most senior class is priced at a discount.

Describe the impact of these assumptions on your OAS valuations for the most senior class.

    (d)   (i) Explain the rationale for an issuer to use interest-only (IO) classes in a class structure.

            (ii) Describe the sensitivity of the OAS valuation of an IO class to default losses and involuntary principal payments in a senior-subordinated CMBS deal.

10. *(7 points)* You are the portfolio manager for a United Kingdom domiciled insurance company. The portfolio currently has a U.S. asset of $300,000 with a volatility (s) of 0.02 per day.

You have been asked to evaluate an investment in a Planned Amortization Class (PAC) tranche of a collaterized mortgage obligation, where the mortgage collateral is residential mortgages originated in the U.S. The PAC security you are considering is $200,000 and has an asset volatility (s) of 0.015 per day.

The two assets have a correlation factor of 30%. The change in portfolio value is normally distributed and asset returns have a bivariate normal distribution.

(a) Describe the factors affecting mortgage prepayment modeling.

(b) Describe, in general, the risks associated with political climate risk.

(c) Describe the three distinct categories of currency hedging techniques available for hedging this asset.

(d) Assess the benefit of diversification when adding this PAC security to the portfolio, using a 5-day, 95% VAR. Show your work.

11. *(6 points)* Your company has a portfolio of investment-grade bonds and mortgage-backed securities (MBS) with an option-adjusted duration of 4 years. The portfolio supports a closed block of single premium deferred annuities (SPDAs) with minimum rate guarantees of 5%.

The company, using the portfolio yield method, declares the crediting interest rates monthly. However, the V.P. of marketing strongly recommends that the credited rate be based on current market rates.

The company's economist has forecast the following interest rates under two economic scenarios:

	Current Environment	Recession Scenario	Inflation Scenario
10 Year T-Note Yield	6%	4%	8%
90 Day T-Bill Yield	5%	3%	11%

(a) Predict the effects on your company's asset portfolio and the SPDA block using each interest rate crediting methodologies under the following:
   (i)   recession scenario
   (ii) inflation scenario

(b) Explain why it may be disadvantageous to reposition the portfolio using outright sales and purchases.

(c) Describe option strategies to hedge against a movement from the current environment to:
   (i)   recession scenario
   (ii) inflation scenario

(d) Describe the risks related to the options strategies used in (c).

12. *(6 points)* XYZ Life Insurance Company originates home equity loans to elderly homeowners. The loan is not due for repayment until the borrower dies or moves out of the property. The amount of the initial loan is based on the age of the borrower and the property value. Interest and fees are accumulated until repayment. The only source of repayment is the property.

A government institution provides insurance against the risk that the eventual repayment amount is less than the loan balance at that time. The premium, which is added to the loan balance, is an initial fee of 2% of the loan value and 0.5% of the outstanding loan balance annually. The homeowner can repay in full at anytime without penalty.

The loan interest rate is reset every six months. The net rate of interest, after insurance premium and expenses, is the rate on 6 month CD's plus 3%. Based on projected cash flow, the company issues GICs of 1, 3 and 5-year maturities.

The following three strategies have been proposed:
        (i)   Issue fixed rate instead of variable rate loans.
        (ii)   Swap the variable interest rates for fixed interest rates.
        (iii)   Purchase insurance against the risk of homeowners dying earlier or later than expected.

(a)   Analyze the risks associated with the current strategy.

(b)   Describe the risks associated with the three proposed strategies.

13. *(7 points)* You are given the following information about a European put option on a non-dividend paying stock:

- Stock price   40

- Risk-free interest rate   7% (continuously compounded)

- Strike price   35

- Time to maturity   8 months

You are also given the following volatilities derived from actively-traded European call options on the stock:

Time to maturity	Strike Price			
	30	35	40	45
3 months	0.290	0.225	0.180	0.150
6 months	0.280	0.230	0.230	0.160
1 year	0.275	0.236	0.221	0.180

(a)   Calculate the price of this option using the Black-Scholes formula. Show your work.

(b)   Contrast the stock price distribution implied by the volatility matrix with the log-normal distribution.

(c)   Describe models of stock price behavior that are consistent with the implied distribution.

14. *(5 points)* The asset portfolio of a U.S. life insurance company includes real estate properties. The portfolio manager is currently considering adding to the portfolio an equity investment in an office building in Atlanta. The building is fully leased at fixed rates with 10 years remaining on its leases and subject to a mortgage equal to 50% of its current market value. The mortgage is for 10 years, interest-only, and interest is paid monthly at 1 month LIBOR plus a fixed spread.

(a)   Evaluate the risks of this specific investment.

(b)   Propose approaches to reduce the risks identified in (a).

15. *(7 points)* The debt of Company X consists of one zero coupon bond with the following payment probabilities at maturity:

	Default Risk Probabilities	
	Real World	Risk-Neutral
No default	85%	75%
Default with 70% recovery	10%	15%
Default with 35% recovery	5%	10%

Additional information is as follows:

- Debt maturity — 5 Years
- Payment due at maturity — 1000
- Risk-free rate — 5% (continuously compounded)

Company Z has written a European option which will pay 1000 in 5 years in exchange for Company X's debt.

Assume Company X and Z have equal but independent default risk.

(a)   Calculate the market's expected spread for the bond over the risk-free rate. Show your work.

(b)   Determine the possible payoffs at maturity of a European option written by Company Z which will pay 1000 in 5 years in exchange for Company X's debt.

(c)   Calculate the value of this option. Show your work and state your assumptions.

16. *(6 points)* You are given the following information about two estimations of the Market Value (MV) of the total policy liabilities of a life insurance company:

Method used	Estimation
MV (Liability)	$2.0 billion
MV (Asset) – MV (Equity)	$1.8 billion

(a) Contrast the two methods.

(b) Explain how the uncertainty of cash flows can be reflected in the estimation of the market value under the MV (Liability) method.

17. *(5 points)*

(a) Describe the following fixed income risk measures:

  (i) prepayment uncertainty,

  (ii) volatility risk (vega),

  (iii) zero volatility spread (ZVO),

  (iv) spread duration.

(b) Your company's fixed income portfolio contains MBS, CMBS, CMO, ARM, callable and putable corporate bonds, and ABS. Explain the impact of each of the risk measures above on the different fixed income asset classes.

** END OF EXAMINATION **
AFTERNOON SESSION