

**November, 2001- Course 8V
Society of Actuaries**

**** BEGINNING OF EXAMINATION **
MORNING SESSION**

Questions 1 – 4 pertain to the Case Study This question should be answered independently.
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- 1.** (12 points) LifeCo is concerned that it may not reach its profit target from international activities due to adverse currency movements. Less than 50% of the currency exposure is currently hedged using currency swaps and forwards for selected countries based on net cash flow projections for each country.

A group has been established to manage the overall currency risk of LifeCo. Its mandate is to measure the worst case scenario exposure at a 95% confidence level, review the currency hedging strategy and propose a method to allocate the return from international activities to the appropriate business units. It is expected that the allocation formula will allow the company to evaluate the performance of its foreign operations converted into local currency and the impact of managing the currency risk.

The results for the worst case scenario exposure are:

VAR based on historical simulation	500,000
VAR based on the delta-normal method	800,000

- (a) (4 points) Contrast the considerations in the selection of a target level of currency hedging in general versus LifeCo.
- (b) (3 points) Describe alternative techniques to manage the currency risk that would be suitable given LifeCo's objectives.
- (c) (3 points) Compare the two methodologies used by LifeCo to calculate VAR.
- (d) (1 point) Define the concept of transfer pricing and explain how it can be used for LifeCo's performance assessment.
- (e) (1 point) Describe the application of a transfer pricing methodology to attribute the return from international activities to appropriate sources for LifeCo.

Questions 1 – 4 pertain to the Case Study
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- 2.** (8 points) LifeCo currently uses income statement based measurement in its ALM decision making process. You are the ALM actuary for LifeCo and have been asked to research the subject of fair value accounting and its potential applications to performance measurement.
- (a) Compare and contrast a fair value based total return accounting approach to a book value based current accounting approach such as GAAP.
 - (b) Assess the expected impact of using fair value based performance measurement in the ALM decision making process on a long term basis in terms of:
 - (i) asset portfolio return
 - (ii) economic profits (value)
 - (iii) future accounting earnings

2. Continued

- (c) Institutional Pensions-Payout Annuity of LifeCo conducted the pilot test in the first quarter of 2000 to validate the new performance measurement system based on fair value accounting. To isolate the performance of the product from the performance of investments, the Product Division and the Investment Division decided to use the benchmark portfolio that consists of non-callable investment grade corporate bonds to approximately match the liability cashflows. The selected financial data are given below:

		December 31, 1999	March 31, 2000
Book Value (Asset, Liability, Benchmark)		700.0	
Market or Fair Value vs. Book Value Ratio	Asset	1.066	1.090
	Liability	1.085	1.100
	Benchmark	1.065	1.080
Book Yield or Book Valuation Rate ($i^{(1)}$)	Asset	7.28%	7.28%
	Liability	6.75%	6.75%
	Benchmark	7.20%	7.20%
Actual Cashflow	Asset		20.0
	Liability		19.9
	Benchmark		20.8
Realized Book Gain (Loss)	Asset		0.0
	Liability		0.5
	Benchmark		0.0

Calculate the Investment Division's performance and the Product Division's performance (in absolute amount) for the first quarter of 2000 in terms of:

- (i) book value
- (ii) fair value

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- 3.** (8 points) You are an actuary at LifeCo responsible for the management of the guaranteed minimum accumulation benefit (GMAB) included in the variable annuities.
- (a) Describe the alternatives for option pricing stochastic models that can be used to determine the theoretical value of the guarantee.
 - (b) Evaluate the following risk management techniques:
 - (i) running the risk naked
 - (ii) static hedging
 - (iii) dynamic hedging
 - (c) Describe the key considerations for developing an integrated risk management approach for GMAB risk.
 - (d) Recommend changes to LifeCo's ALM policy statement in light of the considerations identified in (c).
 - (e) Formulate the modeling considerations under a simulation approach if LifeCo chooses the following risk management technique:
 - (i) holding sufficient funds to cover expected losses within a specified tolerance level
 - (ii) dynamic hedging

Questions 1 – 4 pertain to the Case Study
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- 4.** (12 points) You are a consulting actuary hired by LifeCo to review their operational guidelines for managing the credit risk of derivatives. You have been asked to recommend and describe a methodology for integrated modeling of market and credit risk.

You decide that the Mark-to-Future (MtF) methodology is the appropriate framework for this assignment.

- (a) (2 points) Critique LifeCo's operational guidelines for managing credit risk of derivatives.
- (b) (3 points) Describe risk and reward measures that can be used in the MtF framework for the measurement of:
- (i) market risk
 - (ii) credit risk

Define all terms.

- (c) (2 points) Describe each of the following approaches to credit risk measurement and compare them to the approach used by LifeCo.
- (i) counterparty exposure models
 - (ii) portfolio credit risk models
- (d) (5 points) Describe the steps involved in implementing an integrated market and credit risk framework for measuring the risks in LifeCo's derivatives portfolio.

- 5.** (6 points) Company X is a seller of very large fixed rate long-term GICs to institutional investors. The company is considering approaches for hedging interest rate risk.
- (a) Describe the considerations associated with warehousing assets in anticipation of issuing a GIC.
 - (b) Describe the considerations associated with hedging the interest rate risk between the time the GIC rate commitment is made and the time the proceeds are invested when assets have not been warehoused.
 - (c) Describe the advantages and disadvantages of using each of the hedging instruments identified below to hedge the risks identified in (a) and (b).
 - (i) government bonds
 - (ii) government bond futures
 - (iii) interest rate swaps

6. (6 points) You are the pricing actuary for a life company that sells EIAs with the following product features:

Product Features	
Term to maturity	10 years
Design	point-to-point
Underlying index	S&P 500
Minimum guarantee	90% of the premium accumulated at 3%
Payout to the contract holder	greater of the guaranteed minimum, or 100% of the increase in the price of the index over the 10 year period

Your company has just sold 10 million in premium. Market conditions are as follows:

Market Conditions	
Current index value	100
Expected annual index return	13%
10-year implied volatility on OTC call options	15%
Risk-free rate	5%
Term of available futures contracts	1 year
Contract size of available futures contracts	100,000

Two investment strategies are being considered for this product:

- buy fixed income bonds and 10-year OTC call options
- buy fixed income bonds and replicate the embedded option through delta hedging with index futures

- (a) Compare and contrast the two strategies with respect to:
- costs
 - risks
 - effectiveness in matching the liability
- (b) Calculate the futures transaction necessary to hedge your company's position at issue using the delta hedging strategy.

7. (4 points) Describe the differences between modern finance theory and empirical studies of corporate management.
8. (4 points) A mid-size publicly traded company's recent decision to increase dividend payments to their shareholders was not well received by the market.
- (a) Describe the arguments for and against dividend payments.
 - (b) Describe the market myths of "market myopia" and "supply and demand" and offer some evidence or arguments that are contrary to these myths.

****END OF EXAMINATION****
MORNING SESSION

**** BEGINNING OF EXAMINATION ****
AFTERNOON SESSION

9. (5 points)

You are given:

- f is a derivative security with payoff f_T at T and 0 elsewhere
 - interest rate, r , is stochastic
 - money market account is the numeraire
- (a) Define a martingale process and state the equivalent martingale measure result. Define all terms.
- (b) Prove that $f = \hat{E}(e^{-\bar{r}T} f_T)$ using the equivalent martingale measure.

- 10.** (7 points) Policyholder lapse behavior has often been compared to the prepayment behavior observed in mortgage-backed security (MBS) collateral.

You are given the following policyholder lapse assumption for a single premium deferred annuity (SPDA).

$$\text{SPDA lapse rate} = \text{Max} (\text{Base lapse} + \text{Excess lapse}, 0)$$

where

$$\text{base lapse} = \begin{cases} 1\% \times (y / 2) + 2\% & \text{for } y < 5 \\ 30\% & \text{for } y = 5 \\ 5\% & \text{for } y > 5 \end{cases}$$

$$\text{excess lapse} = \begin{cases} (CR - CP - SC / 3)^2 & \text{for } CR > CP + SC / 3 \\ 0.5 \times (CR - CP - SC / 2) & \text{otherwise} \end{cases}$$

y = years from issue

CR = credited rate, reset annually, minimum guarantee of 4%

CP = competitor rate = max (90-day Treasury rate + 70bp, 5-year Treasury rate)

SC = surrender charge, 5-year declining schedule

- Identify and describe the four basic determinants of MBS collateral prepayment behavior.
- Explain, for each of the four determinants, whether they are present or absent in this lapse assumption.
- Describe the lapse rate variance for each item in (b) that would occur over time if the item is ignored.
- Describe the steps needed to calculate the required spread on assets (RSA) using the approach as described by Griffin for an SPDA at the time it is issued.
- Describe how the lapse assumption error in (c) would affect the RSA at the time of the policy's issue in the situation where the initial yield curve is relatively steep.

- 11.** (7 points) You have been asked to evaluate the use of exotic options to hedge the impact of a market downturn on management fees from equity-linked products. These management fees are earned continuously.
- (a) Describe the payoff at maturity associated with the following:
 - (i) straddle
 - (ii) down-and-in put with barrier $H < X$, where X is the strike price
 - (iii) average price put
 - (iv) forward start at-the-money put option starting at time T_1
 - (v) lookback put
 - (b) Assess the potential usage of each of the options listed in (a) to:
 - (i) Guarantee a minimum level of fees on equity-linked products for the current portfolio.
 - (ii) Guarantee a minimum level of fees on equity-linked products for deposits made during the next time period.
 - (c) Describe the trinomial valuation method and compare its application in valuing barrier options and American options.

12. (7 points) Consider the following portfolio of variable deferred annuities:

Separate account assets (MV)	700,000 in S&P 500 index fund
Fixed account assets (BV)	100,000 yielding 6%, duration 4
Fixed account liabilities (BV)	100,000 crediting 5%
Guarantees on variable accounts	none
Minimum guarantee on fixed account	3% annual credited rate
Management fees	150 basis points per year charged on MV of separate accounts
Fixed expenses	3,000 per year

You are given the following annual rates:

Risk-free rate	4.50%
S&P 500 index expected return	15%
Dividend yield	0%
Volatility on S&P 500	20%

Strike	d1	d2	N(d1)	N(-d1)	N(d2)	N(-d2)
100	0.1625	0.0625	0.5645	0.4355	0.5249	0.4751
95	0.6754	0.5754	0.7503	0.2497	0.7175	0.2825
90	1.2161	1.1161	0.8880	0.1120	0.8678	0.1322

Ignore capitalized expenses, target surplus, taxes, lapse, transfers, and CARVM expense allowances. The assets in the separate account have minimal basis risk with the traded equity index.

- (a) Calculate the mean and standard deviation of the rate of return (continuously compounded, before management fees) on the separate account assets for a 3 month period using the normal model.
- (b) Assuming that the average separate account assets during the next 3 months are half of beginning and ending values from (a):
 - (i) State the equation for expected pretax income over the next 3 months.
 - (ii) Calculate the expected pretax income over the next 3 months.

12. (Continued)

- (c) Calculate a 95% confidence interval for gross rate of return on separate account funds over the next 3 months.
- (d) Estimate a 95% confidence interval for pretax income over the next 3 months. Assume that average separate account assets are half of beginning and ending amounts calculated in (c).
- (e) Calculate the percentage change in pretax income versus expected, for each bound in (c).
- (f) Calculate the expected ratio of pretax income to the range of a 95% confidence interval.
- (g) Calculate the prices for 90-day European put options on the S&P 500 index with strike prices at 100, 95 and 90.
- (h) Fixed assets are liquidated to partially hedge income volatility by purchasing a put option contract with a strike price of 95. The notional amount of each put option contract is equal to the expected pretax income from (b) above.
 - (i) Calculate the price for the hedge.
 - (ii) Recalculate the expected return and the 95% confidence interval calculated in (d) for the hedged portfolio.
 - (iii) Recalculate the ratio in (f) for the hedged portfolio.

- 13.** (6 points) You are the chief risk officer for a life insurance company. A Wall Street vendor of model analytics has approached you with their latest interest rate modeling product. The vendor claims that it is a realistic, arbitrage-free term structure model which should be appropriate for most of your ALM and reserve adequacy testing projects.
- (a) Evaluate the appropriateness of the term structure model proposed by the vendor.
 - (b) Describe the categorization of approaches to term structure modeling and the resulting four classes of interest rate models.
 - (c) Outline the specific uses and limitations of the four classes of interest rate models.

- 14.** (6 points) The current price of a stock, S , is 5 and the price follows a generalized Wiener process with a mean of 10% of its price and a volatility of 20% of its price. Another security, G , is derived from S by the formula: $G = S^2 + S + 1$. Two students have been asked to use Ito's lemma to determine the dynamics of a position of 1 unit of G hedged with a position $H(S)$. The students used the following formulas:

Student A $H(S) = 1 - S^2$

Student B $H(S) = S^2 - 10S + 1$

- (a) Determine the position in S that is needed to hedge a long position of 1 unit of G .
- (b) Using Ito's lemma:
 - (i) Determine the process that the hedge position would follow under each student's formula.
 - (ii) State which formula should be used to understand and manage the dynamics of the hedge position. Justify your choice and explain why the other formula is not appropriate.

- 15.** (5 points) XYZ Life has proposed changing its management compensation plan to separately reflect performance of asset and liability components. You have been asked to use the Total Return Approach to Performance Measurement to execute the new compensation plan.

Describe the total return attribution analysis for the following:

- (a) portfolio of tradeable securities
- (b) liabilities
- (c) net profits

Define all terms.

- 16.** (8 points) You are given the following information for BBB-rated zero coupon corporate bonds:

Term (years)	Current Price	Average Cumulative Default Probabilities	Recovery Rate Upon Default
5	70.470	3.00%	40%
10	48.675	13.00%	40%

You are also given:

- The principal payment due at maturity is 100.00.
 - The corporate zero coupon yields are continuously compounded.
 - The risk-free rate is 5.50% per year (continuously compounded).
- (a) Calculate the value, at time zero, of expected losses from default on BBB-rated zero coupon corporate bonds based on the current bond prices for the following future time periods:
- (i) during the first 5 years
 - (ii) during the first 10 years
 - (iii) between years 5 and 10
- (b) Compare the estimates of future default, based on the current bond prices, with the historical default experience on BBB-rated zero coupon corporate bonds for the same time periods stated in (a).
- (c) Describe the possible reasons for the discrepancy between actual default experience and the default probabilities implied in bond prices. Explain how each of these can be used in the analysis of credit risk.
- (d) Calculate the annual returns that an investor can expect to earn, on average, in excess of those in a risk-free world for both the 5-year and 10-year BBB-rated zero coupon corporate bonds, given the extent of the discrepancy between actual default experience and the default probabilities implied in bond prices.

17. (3 points) Describe each of the following:

- (a) Option Pricing Method (OPM)
- (b) Actuarial Appraisal Method (AAM)
- (c) The circumstances under which AAM is equivalent to OPM.

18. (6 points) You are the pricing actuary and are considering the following design for a new 5-year EIA:

- point-to-point with a 2-year Asian end and a participation rate of 80%
- annual discrete lookback with a participation rate of 50%
- annual discrete lookforward with a participation rate of 60%
- annual simple ratchet with a participation rate of 100% and an annual cap of 12%
- point-to-point ladder design with a 125 "rung" at year 3 and a participation rate of 90%

You have been given the following projected equity index scenario:

Time in Years	0	1	2	3	4	5
Anniversary Index Level	100	130	110	120	150	140

- (a) Calculate the value of a 100,000 premium deposit at the end of five years under each 5-year design assuming no withdrawals.
- (b) Compare the advantages and disadvantages of stochastic versus deterministic scenario testing in EIA pricing.

**** END OF EXAMINATION ****
AFTERNOON SESSION