****BEGINNING OF EXAMINATION 8****
INVESTMENT
MORNING SESSION

Questions 1 – 5 pertain to the Case Study

1. *(6 points)* LifeCo's management would like to apply fair value accounting principles to a new group medical insurance policy with the following characteristics:

- The term of the policy is one year.
- The expected year-end claims and associated expenses is $750.
- The risk-free rate is 5%.
- The tax rate is 35%.
- Assume the total return on assets supporting LifeCo's group business is equal to the book yield on those assets.
- Information on LifeCo's key competitors is given below:

Competitor	Total Return on Assets	Return on Equity	Ratio of Equities to Liabilities
A	6.00%	12%	15%
B	6.25%	14%	17%
C	6.75%	16%	20%
D	7.50%	20%	25%
Weighted Average	**6.50%**	**15%**	**18%**

(a) List the hierarchy of methods to determine the fair value of financial instruments and propose the most appropriate method for LifeCo's group business.

(b) Calculate the fair value of the new group medical policy using the Cost of Capital approach.

(c) Define the term Market Value Margin (MVM) and calculate the MVM for the above policy.

Questions 1 – 5 pertain to the Case Study

2. *(6 points)* LifeCo senior management wants to rebalance its Traditional Life Products portfolio in order to achieve the following objectives:

- immunize the portfolio on an effective duration basis
- maximize return on required capital
- achieve a positive spread contribution

(a) Analyze the asset classes supporting the Traditional Life Products portfolio with respect to the rebalancing objectives.

(b) Describe the bond trading issues that may affect LifeCo's ability to achieve its objectives.

3. *(7 points)* LifeCo's ALM Committee is conducting its annual review of the investment strategies for the portfolios backing the Traditional Life and Non-Traditional Life liabilities. The CFO has expressed an interest in increasing the emphasis on real estate investments for the Life portfolios and has asked for additional information on market efficiency and how to create a portfolio management process. The Committee is also reviewing the various ALM guidelines and policies as part of the review process.

(a) Describe the investment risks associated with the liabilities for each of these two segments.

(b) Recommend a portfolio management process suitable to real estate investing in response to the CFO's inquiry.

(c) Evaluate the Asset Liability Management procedures at LifeCo.

Questions 1 – 5 pertain to the Case Study

4. *(5 points)* LifeCo's investment department is interested in increasing the proportion of high-yield bonds in the surplus account. However, the Board of Directors is reluctant to approve this request since:

- high yield bonds receive poor ratings through traditional credit analysis
- any restructuring involves significant costs

(a) *(1 point)* Assess whether LifeCo's current investment policy needs to be modified to permit the proposed strategy change.

(b) *(4 points)* Contrast traditional credit analysis and dynamic credit analysis.

5. *(6 points)* In response to the recent review by the M&P rating agency, LifeCo's Board has mandated implementation of a best-practices risk management framework and appointed you Chief Risk Officer.

(a) Compose a liquidity risk management program that addresses the rating agency's concerns.

(b) Compose a credit risk management program that addresses the rating agency's concerns.

(c) Compose an operational risk management program for LifeCo's derivatives unit.

6. *(5 points)* Your company is selling an Equity Indexed Annuity (EIA) product with a compound annual ratchet guarantee and no life-of-contract guarantee. You are given the following information about the contract and the current pricing environment:

Initial premium	100
Term of the contract	7 years
Participation rate	50%
Risk free rate	6% (continuously compounding)
Dividend yield of reference equity index	2% (continuously compounding)
Annual volatility of reference equity index	20%

Your company is also selling a variable annuity (VA) product with the following Guaranteed Minimum Maturity Benefit rider:

Term to maturity	until age 75
Guarantee	75% of premiums, less withdrawals
Reset	at policyholder request until age 65, limited to twice a year

(a) Compare the product features and risk management for the EIA to the VA above.

(b) Define the ratchet premium EIA benefit and calculate its value using the Black-Scholes approach.

7. *(6 points)* You are analyzing a swaption that gives the company XYZ Re the right to pay, 5 years after issue of the swaption, a fixed rate in the following swap:

Notional amount	$1,000,000
Variable rate	LIBOR (continuous compounding)
Fixed rate	5.2% (semi-annual compounding)
Payments	semi-annual
Term	1 year
Volatility	20%

(a) Calculate the swaption premium assuming the LIBOR yield curve is flat at 5% at the time of issue.

(b) Categorize the possible outcomes and default options to both parties during the life of this transaction.

(c) Propose how XYZ Re can hedge the risk of default by the swaption counterparty by using a credit default swap.

8. *(6 points)* You have been asked by the chief investment officer (CIO) of a life insurer to develop risk management strategies for a new non-par level premium whole life insurance policy. The company has already set the premium level based on current fixed income yields. The CIO is concerned about the possibility that fixed income yields will be lower in the future, in which case the product will not achieve its profit objectives.

The Marketing VP thinks that hedging is not necessary because the company has a deferred annuity product that should experience gains if interest rates fall due to the company's ability to lower the annuity product crediting rate.

(a) Appraise the effectiveness of the deferred annuity product in providing a "natural hedge" to the whole life policy.

(b) Recommend one strategy that uses derivatives to hedge against falling rates and allows the company to earn a spread over swap rates. Describe the benefits and risks associated with your strategy.

(c) Recommend one strategy that allows the company to lock in today's yields on future premiums. Describe the benefits and risks associated with your strategy.

9. *(5 points)* You are using a lognormal distribution with annual parameters μ and σ to model stock price movements for valuing products with a Guaranteed Minimum Maturity Benefit (GMMB).

The valuation method requires the model to be calibrated based on the following accumulation factors associated with the left-tail of the distribution accumulated over specific time periods:

Accumulation period	**2.5% th Percentile of the accumulation factor**
1 year	0.75
5 years	0.77

(a) Explain why a left-tail calibration method is appropriate when using the "actuarial" approach for valuing GMMB.

(b) Determine the parameters μ and σ using the calibration method.

(c) Evaluate the advantages and disadvantages of using the regime-switching lognormal model compared to the calibrated lognormal model.

10. *(8 points)* You are the Chief Actuary of a company that is writing GICs with 2-, 4-, and 6-year maturities. One of your actuarial students has recommended the use of PACs as an asset class to back the liabilities. You will need to evaluate the appropriateness of this recommendation.

(a) Describe the features of PAC tranche CMOs.

(b) Explain how the market value of PAC tranche CMOs is affected by whether the bonds are bought at a premium or discount.

(c) Distinguish PACs from MBS passthroughs.

(d) Describe in detail prepayment behavior considerations.

(e) Describe the specific PAC features you would find desirable for minimizing risk of the GIC product line.

****BEGINNING OF EXAMINATION 8****
INVESTMENT
AFTERNOON SESSION
Beginning with question 11

11. *(7 points)* Your company issues SPDAs and currently uses the excess spread approach to pricing.

Contract size	$10,000
Upfront expense per contract	$1,000
Crediting strategy and renewal expense	30bp
Average life of the liability	10 years

Your company is using Corporate A bonds yielding 110bp above Treasuries to support the liability assuming the asset related costs are 25bp.

(a) Describe the excess spread approach to pricing.

(b) Calculate the Required Spread on Assets (RSA).

(c) Calculate and interpret the excess spread.

A Co-op student has suggested that the excess spread approach may have some limitations. The student suggests using either interest rate caps and floors or a swap.

(d) Criticize the excess spread approach.

(e) Describe how interest rate caps and floors could be used to price SPDAs.

(f) Describe how an interest rate swap could be used to price SPDAs.

12. *(6 points)* You are using the contingent claim approach to evaluate a block of French "with profits" policies. The current liability of the block is valued at $95 million with supporting assets of $100 million.

Time to maturity	5 years
Guaranteed fixed interest rate	4% (continuously compounding)
Participation level	85% of net profits
Total volatility of assets	20%
Default-free 5 year zero-coupon bond price P(0,5)	0.8

(a) Describe the embedded options for both the company and the policyholders.

(b) Calculate the current value of the embedded options and hence the shareholders' equity.

(c) Solve for the participation level that would avoid any subsidy between the company and policyholders.

13. *(6 points)* Your company's liabilities consist of single premium fixed deferred annuities. In the past, your portfolio manager has been directed to match the modified duration of the liabilities. A recent study of Key Rate Durations was conducted for the liabilities, and the asset Key Rate Durations have been provided by your portfolio manager. Assets and liabilities are both valued at $1,000,000. You have the following information:

	Liability Key Rate Duration	**Asset Key Rate Duration**	**Current Spot Curve**	**Scenario 1 Parallel Shift Up 100 bps**	**Scenario 2 Steepening Spot Curve**
3 month			4.75%	5.75%	4.75%
1 year			4.80%	5.80%	5.00%
2 year			4.85%	5.85%	5.25%
3 year	2.00		4.90%	5.90%	5.50%
5 year	1.50	6.50	4.95%	5.95%	5.75%
7 year	2.00		5.00%	6.00%	6.00%
10 year	1.00		5.05%	6.05%	6.25%
15 year			5.10%	6.10%	6.50%
20 year			5.15%	6.15%	6.75%
25 year			5.20%	6.20%	7.00%
30 year			5.25%	6.25%	7.25%

(a) Calculate the change in net present value under Scenarios 1 and 2.

(b) Construct a portfolio of zero-coupon Treasury bonds that immunizes the liabilities on a Key Rate Duration basis.

(c) Explain whether the portfolio in (b) completely eliminates all exposure to interest rate risk.

14. *(6 points)* ExposedCo Inc. is an international manufacturing business headquartered in the United States. Its balance sheet and income statement are exposed to changes in foreign exchange rates. ExposedCo wishes to analyze its current foreign exchange rate risk exposure and formulate a suitable hedging strategy.

ExposedCo's operations are located as follows:

- Headquarters: United States
- Research Facility: Canada
- Manufacturing: China
- Sales: Europe

ExposedCo's objectives are to minimize:

- gains/(losses) from changes in foreign exchange rates
- the cost of implementing a hedging strategy

Sales related expenses are equal to 20% of revenue.

(a) *(1 point)* Identify ExposedCo's foreign exchange rate risk exposures.

(b) *(5 points)* Describe how you would use the Merck model to develop a hedging strategy for ExposedCo's foreign exchange rate risk exposures.

15. *(6 points)* You are consulting to the trustees of a large corporate defined benefit pension fund regarding the expected long-term rate of return on the plan's fixed income investments. The trustees are worried that the expected return assumption used to determine annual contributions is too high and should be lowered. The company's chief financial officer (CFO) tells you that she believes that interest rates are temporarily low due to Federal Reserve policy and expects them to rise toward their long-term average. She points to the upward sloping yield curve as evidence, stating that, "forward rates are telling us that future yields will be higher."

You are given the following current economic data and assumptions.

Forecast for long-run growth in labor productivity	2.50%
Forecast for long-run growth in labor force	0.90%
Current yield on 10-year treasury bond	4.50%
Current yield on 10-year inflation-indexed treasury bond	1.80%
Estimate of inflation risk premium	0.30%
Estimate of equilibrium excess return of aggregate portfolio over 10-year treasury bonds	0.35%
Long-term average yield on aggregate fixed income portfolio	7.50%
Current assumption for expected long-term return on the fixed income assets used to determine plan contributions	7.50%

(a) *(3 points)* Project the equilibrium yield on the plan's aggregate fixed income portfolio.

(b) *(1 point)* Describe the particular theory of the term structure of interest rates that would support the CFO's comment regarding future yields.

(c) *(1 point)* Assess whether the empirical evidence supports or rejects the theory.

(d) *(1 point)* Formulate a recommendation for the trustees.

16. *(5 points)* Consider a 3 year down-and-out put option on S&P total return Index where:

S&P index	1300
Strike price	1300
Barrier	1200
Risk free rate	5% effective annual
Volatility	22% per annum
Time Step	Annual

You are given the following European put option prices on the S&P index, total return basis:

Put Option	Index level	Strike	Term (Year)	Price
A	1200	1200	1	75.91
B	1200	1200	2	91.36
C	1200	1200	3	97.84
D	1200	1300	1	126.00
E	1200	1300	2	135.33
F	1200	1300	3	137.57
G	1300	1200	1	45.71
H	1300	1200	2	64.12
I	1300	1200	3	73.31
J	1300	1300	1	82.23
K	1300	1300	2	98.97
L	1300	1300	3	105.99

Construct the replicating portfolio for the down-and-out option from the above options. Provide details of the put options selected and number of units used. Assume that option contracts are infinitely divisible.

17. *(6 points)* You are given the following information about an at-the-money European put option on a dividend paying stock.

Annual volatility	20%
Risk free rate	5% (continuously compounding)
Current stock price	$50
Dividend	$0.25 per quarter
Term of option	1 year (immediately after the 4th dividend)

(a) *(2 points)* List and criticize the assumptions underlying the original Black-Scholes option pricing formula.

(b) *(3 points)* Calculate the price of the put option assuming that the first dividend is paid 3 months from now.

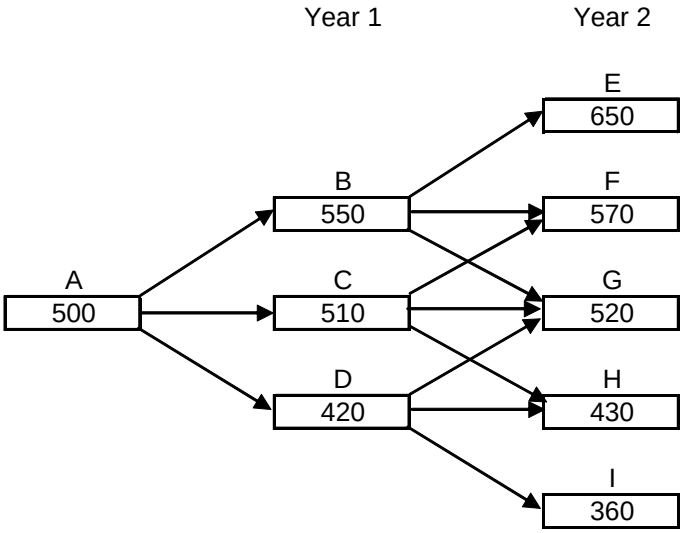
(c) *(1 point)* Define and explain the following volatility concepts associated with the Black-Scholes pricing framework for equity options.

(i) Implied volatility
(ii) Volatility smile
(iii) Volatility surface

18. *(7 points)* A gold mining company is considering investing $30 million in a project to open a new mine. You are given the following information about the project:

- The mine will yield 50,000 ounces of gold per year for the next 2 years.
- Expenses for the proposed mine are $5 million per year and $50 per ounce of gold extracted.
- At the end of year 1, the Company has the option to improve the efficiency of its extraction process for the second year to extract 20% more gold by investing $4 million at the end of year 1. The expense per ounce extracted would increase to $60 with that new technology.
- Assume year-end cash flows once the mine is in operation.
- The continuously compounded risk free rate is 5% for all maturities.

The following trinomial tree displays the spot price of gold (per ounce) over the next 2 years.



The table below shows the probability of moving up, down or staying level for each node listed.

Node	A	B	C	D
Prob up	0.333	0.167	0.333	0.5
Prob medium	0.333	0.333	0.333	0.333
Prob down	0.333	0.5	0.333	0.167

(a) *(1 point)* Describe options embedded in projects, in general, and compare them to American and European calls and puts.

18. **Continued**

(b) *(4 points)* Evaluate the project to start the new mine and recommend whether or not the company should undertake it.

(c) *(2 points)* Explain why the company's actual decision might differ from your recommendation in (b).

19. *(5 points)* You are using Monte Carlo simulation to calculate the value of a 1-year at-the-money European call option on a portfolio of two stocks that pay no dividends. You are given the following information regarding the two underlying stocks:

Stock	Number of stocks in portfolio	Current price of the stock	Expected 1-year log-return	Expected 1-year volatility	Correlation of log-returns with stock 1
1	1	$100	5%	10%	1.00
2	1	$50	8%	20%	0.80

You use a lognormal process for stock prices with 1-year time steps. Assume that the composition of the portfolio does not change during the year. The risk-free rate is 4% compounded continuously.

(a) Describe the calculation of the call price using Monte Carlo simulation.

(b) Calculate a sample payoff of the call option at the end of the year that you would use to price the option. Use the following realizations from a standardized univariate normal distribution.

Sample	Normal Random Number
1	0.4
2	0.7

(c) Describe the antithetic variable technique for variance reduction.

20. *(6 points)*

(a) (*1 point*) Define the following Greeks:

(i) Delta

(ii) Gamma

(iii) Rho

(iv) Vega

(b) (*2 points*) Sketch the curve of each of the above Greeks as a function of time to maturity for an at-the-money put option on a non-dividend paying stock.

(c) (*3 points*) Explain the reasons for the shapes of the curves in (b).