

**Society of Actuaries
Course 5**

Application of Basic Actuarial Principles

Morning Session

SECTION A - WRITTEN ANSWER

Illustrative Solutions
from
Fall 2002

Question No. 1

(5 points) With respect to retirement income security for an employee covered by an employer sponsored retirement plan:

- (a) Describe the major risks to retirement income security.
- (b) Describe how the retirement plan can be designed to address these risks.

Question 2

(8 points) With respect to the product development for a fixed premium universal life product:

- (a) Describe the feasibility of developing such a product.
- (b) Describe the issues involved in the product design.
- (c) Describe the pricing pitfalls.

Question 3

(6 points)

- (a) Describe the following loss reserving methods used by property and casualty actuaries:
- (i) Case reserves plus method
 - (ii) Expected loss ratio method
 - (iii) Bornhuetter-Ferguson method
- (b) Calculate the expected ultimate incurred losses for Accident Year 2000 and Accident Year 2001 based on the following claims data through September 30, 2002. Development year 4 is the ultimate year.

Accident Year	Development Year				
	0	1	2	3	4
1998	4,869	5,843	6,468	6,727	6,861
1999	6,593	8,175	9,075	9,347	
2000	8,501	9,946	10,841		
2001	10,293	12,557			
2002	12,678				

Show all work and calculations.

Question 4

(3 points) With regard to life insurance policy acquisition costs:

- (a) Describe the following three types of life insurance commission patterns and give an example of each:
 - (i) Heaped
 - (ii) Levelized
 - (iii) Level
- (b) Describe the issues a company should consider before adopting a levelized or level commission structure for life insurance.

Question 5

(6 points) You are the life insurance pricing actuary for ABC Company and asked to design a new product. You are given the following financial projections:

After-Tax Solvency Earnings, Year 1	150
After-Tax Solvency Earnings, Year 2	250
After-Tax Solvency Earnings, Year 3	300
After-Tax Solvency Earnings, Year 4	500
After-Tax Solvency Earnings, Year 5	800
Solvency Reserves, Year 1	600
Solvency Reserves, Year 2	1,200
Solvency Reserves, Year 3	1,800
Solvency Reserves, Year 4	900
Solvency Reserves, Year 5	0
After-Tax Interest Rate	5.00%
Hurdle Rate	10.00%

- (a) Calculate the following:
- (i) the embedded value at issue
 - (ii) the return on assets
 - (iii) the accumulated profit as a percentage of reserves at the end of year 3
- (b) Describe other profit measures that can be used to compare life insurance products.

Show all work and calculations.

Question 6

(5 points) With respect to individual life insurance,

- (a) Describe the factors which lead to variations in mortality.
- (b) Describe the considerations in developing a mortality assumption for a new preferred risk class.

Question 7

(6 points) With respect to life insurance policies, outline the taxation of policyholders in Canada and the U.S.

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SECTION B - MULTIPLE CHOICE

- 1.** This question consists of two lists. In the list at the left are two items, lettered X and Y. In the list at the right are four items, numbered I, II, III and IV. EACH of the lettered items is related in some way to EXACTLY TWO of the numbered items. Match the lettered items (X and Y) with the numbered items (I, II, III, and IV) shown below.

Indicate the related items using the following answer code:

	<u>X</u>	<u>Y</u>
(A)	I and II	III and IV
(B)	I and III	II and IV
(C)	I and IV	II and III
(D)	II and III	I and IV
(E)	II and IV	I and III
X.	Group insurance product management	I. Ensuring sales are in line with expected goals
Y.	Group insurance plan management	II. Monitoring experience
		III. Ensuring profit margins are realized
		IV. Re-rating

2-7. Each of questions 2 through 7 consist of an assertion in the left-hand column and a reason in the right-hand column. Code your answer to each question by blackening space:

- (A) If both the assertion and the reason are true statements, and the reason is a correct explanation of the assertion.
- (B) If both the assertion and the reason are true statements, but the reason is NOT a correct explanation of the assertion.
- (C) If the assertion is a true statement, but the reason is a false statement.
- (D) If the assertion is a false statement, but the reason is a true statement.
- (E) If both the assertion and the reason are false statements.

	<u>ASSERTION</u>		<u>REASON</u>
2.	The projected accrued benefit cost method with level percentage allocation is prohibited by the Internal Revenue Service for funding purposes.	BECAUSE	The projected accrued benefit cost method with level percentage allocation is based on the concept that a participant's annual benefit accruals should reflect his current economic worth to the employer.

	<u>ASSERTION</u>		<u>REASON</u>
3.	For insurance companies, risk-based capital is calculated by applying a covariance adjustment to the risk components.	BECAUSE	In the U.S., insurance risk is assumed to be independent of asset default risk and interest rate risk.

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|---|---|
| <p><u>ASSERTION</u></p> <p>4. Partial disability benefits are a common feature of short-term disability (STD) contracts.</p> | <p><u>REASON</u></p> <p>BECAUSE Administrative costs are minimized when partial disability benefits are added to short-term disability contracts.</p> |
| <p><u>ASSERTION</u></p> <p>5. Individual disability income policies include the waiver of premium benefit as an option to be elected at issue.</p> | <p><u>REASON</u></p> <p>BECAUSE Under an individual disability income policy, the underwriting requirements for the waiver of premium benefit are different than for the underlying coverage.</p> |
| <p><u>ASSERTION</u></p> <p>6. Under a case rate arrangement, the managed care organization pays the lesser of the fixed case rate and the amount of standard billed charges for the services provided.</p> | <p><u>REASON</u></p> <p>BECAUSE Case rate arrangements are used to compensate physicians, in order to control excessive utilization.</p> |
| <p><u>ASSERTION</u></p> <p>7. Marketing to single-employer experience-rated groups is generally through group sales representatives.</p> | <p><u>REASON</u></p> <p>BECAUSE Employee benefit consultants who market to large groups are usually compensated on a fee basis.</p> |

8-12. Each of questions 8 through 12 consists of two lists. In the list at the left are two items, lettered X and Y. In the list at the right are three items, numbered I, II, and III. ONE of the lettered items is related in some way to EXACTLY TWO of the numbered items. Indicate the related items using the following answer code:

	<u>Lettered Item</u>	<u>Is Related to Numbered Items</u>
(A)	X	I and II only
(B)	X	II and III only
(C)	Y	I and II only
(D)	Y	I and III only
(E)	The correct answer is not given by (A), (B), (C) or (D).	

- 8.**
- | | | | |
|----|------------------------|------|---|
| X. | Equity-indexed annuity | I. | Contains a “Window Period”. |
| Y. | CD annuity | II. | An essential feature is a participation rate. |
| | | III. | Many of the hedging securities have to be custom made by banks. |

- 9.**
- | | | | |
|----|-----------------------------------|------|---|
| X. | Yearly Renewable Term reinsurance | I. | Assets are transferred to the reinsurer. |
| Y. | Coinsurance reinsurance | II. | Under the net cash flow method, the impact on reserves depends upon the relationship between reinsurance premium rates and valuation mortality rates. |
| | | III. | Only mortality risk is reinsured. |

- 10.** X. Portfolio method I. Better matches the liability pattern.
Y. Segmentation method II. More complex administration.
III. Better with long duration liabilities with predictable cash flows.
- 11.** X. Opportunistic pricing I. Companies review the prices of other companies and then determine where to set their prices.
Y. Adaptive pricing II. Most common form of competitive pricing behavior.
III. Competition is based mainly on price.
- 12.** X. Employer-sponsored life insurance I. Used by employer to fund some of employer's future employee obligations.
Y. Corporate-owned life insurance II. Death benefits are usually restricted to a multiple of the employee's salary.
III. Used by employer as an additional employee benefit.

13. Plan effective date: January 1, 2002

Actuarial cost method: Frozen Initial Liability (Entry Age Normal)

Selected valuation results on January 1, 2002:

Present value of future benefit	\$23,500
Entry Age Normal accrued liability	\$18,400
Actuarial value of assets	450
Present value of average working life annuity	15.0

Calculate the Frozen Initial Liability (Entry Age Normal) normal cost at January 1, 2002.

- (A) 310
- (B) 340
- (C) 370
- (D) 1,227
- (E) 1,537

14. An accumulation annuity guarantees a credited interest rate of 5.00% for the remaining four years. The four-year interest rate available on new deposits is 6.00%. If the annuity has a market value adjustment equal to 95.20% of the cash value, how much additional margin is the issuer providing for itself?

(A) 0.30%

(B) 0.51%

(C) 1.07%

(D) 1.13%

(E) 4.29%

15-20. Each of questions 15 through 20 consist of an assertion in the left-hand column and a reason in the right-hand column. Code your answer to each question by blackening space:

- (A) If both the assertion and the reason are true statements, and the reason is a correct explanation of the assertion.
- (B) If both the assertion and the reason are true statements, but the reason is NOT a correct explanation of the assertion.
- (C) If the assertion is a true statement, but the reason is a false statement.
- (D) If the assertion is a false statement, but the reason is a true statement.
- (E) If both the assertion and the reason are false statements.

	<u>ASSERTION</u>		<u>REASON</u>
15.	Classification of risk is essential to the insurance business.	BECAUSE	Classification of risk allows insurers to avoid over-pricing insurance products.

	<u>ASSERTION</u>		<u>REASON</u>
16.	Under universal life contracts, policy loans tend to have high capital requirements.	BECAUSE	Under universal life contracts, policy loan utilization rates may exceed 100%.

- | | |
|--|--|
| <p><u>ASSERTION</u></p> <p>17. It is a commonly accepted principle of rating individual health insurance that a policyholder's original rating class be preserved upon renewal.</p> | <p><u>REASON</u></p> <p>BECAUSE For individual health insurance, the creation of a new class subsequent to initial introduction of the policy is prohibited.</p> |
| <p><u>ASSERTION</u></p> <p>18. Under aggregate cost allocation methods for pension plans, actuarial gains and losses are explicitly recognized.</p> | <p><u>REASON</u></p> <p>BECAUSE Under aggregate cost allocation methods for pension plans, actuarial gains and losses are amortized over the remaining service lifetimes of the active participants.</p> |
| <p><u>ASSERTION</u></p> <p>19. With respect to medical expense insurance, the asset share method is the most common method of determining premium rate changes.</p> | <p><u>REASON</u></p> <p>BECAUSE The experience under an insurer's block of current medical expense policies is likely to be substantially different than when the block was originally priced.</p> |
| <p><u>ASSERTION</u></p> <p>20. Adjusted community rating by class allows a Health Maintenance Organization to be more competitive in the marketplace.</p> | <p><u>REASON</u></p> <p>BECAUSE Adjusted community rating by class is a rating method where a group's historical cost experience and utilization are not used to develop an estimated claim cost.</p> |

21. Rank in ascending order (smallest to largest) the following products according to how much investment risk is transferred to the policyholder.

- I. Variable Universal Life Insurance
- II. Unitised-With-Profits Products
- III. Participating Whole Life insurance

- (A) I < II < III
- (B) I < III < II
- (C) II < III < I
- (D) III < I < II
- (E) III < II < I

- 22.** A home, valued at \$100,000, is insured. The insurance company requires 80% of full coverage before it reimburses in full and reimburses pro-rata otherwise.

Rank in ascending order (smallest to largest) the amount the insurer will pay toward reimbursing the homeowner for the damage listed in the table below.

	Insured Value	Damage
I.	\$60,000	\$50,000
II.	\$70,000	\$60,000
III.	\$80,000	\$40,000

- (A) I < II < III
- (B) I < III < II
- (C) II < III < I
- (D) III < I < II
- (E) III < II < I

23-27. Each of questions 23 through 27 consist of two lists. In the list at the left are two items, lettered X and Y. In the list at the right are three items, numbered I, II, and III. ONE of the lettered items is related in some way to EXACTLY TWO of the numbered items. Indicate the related items using the following answer code:

	<u>Lettered Item</u>	<u>Is Related to Numbered Items</u>
(A)	X	I and II only
(B)	X	II and III only
(C)	Y	I and II only
(D)	Y	I and III only
(E)	The correct answer is not given by (A), (B), (C) or (D).	

- 23.**
- | | | | |
|----|---|------|--|
| X. | Earnings-related formula using lifetime earnings in public retirement income systems | I. | More common in developing countries. |
| Y. | Earnings-related formula using “wage base” earnings in public retirement income systems | II. | Favors workers whose earnings rise with age. |
| | | III. | More progressive benefits. |

- 24.**
- | | | | |
|----|--|------|--|
| X. | Activity based expense allocation method | I. | Used for splitting expenses between new and renewal business |
| Y. | Functional expense allocation method | II. | A transfer charge approach |
| | | III. | Retrospectively estimates time spent on activities |

- 25.** X. Interest spread risk I. Liquidity risk
 Y. Interest rate risk II. Investment expense risk
 III. Disintermediation risk
- 26.** X. Group short term disability benefits I. Most companies offer a reducing benefit deductible.
 Y. Group long term disability benefits II. Maximum benefit amounts are typically smaller.
 III. Overall costs are much more volatile.
- 27.** X. Timing differences in taxable earnings I. Research and development tax credits
 Y. Permanent differences in taxable earnings II. Mortality rate used in reserve calculation
 III. Reserves to offset future capital losses

28. Actuarial cost method: Traditional Unit Credit

Normal retirement benefit: \$30 per month for each year of service

Actuarial assumptions:

Interest rate: 7.0%

Pre-retirement decrement other than death: None

Retirement age: 65

Selected January 1, 2002 data for only participant:

	Smith
Exact age at January 1, 2002	45
Exact age at hire	40

At January 1, 2002, the plan was amended to pay a lump sum death benefit equal to the accrued liability.

Selected commutation functions and annuity value:

$$D_{40} = 498736$$

$$D_{45} = 351021$$

$$D_{65} = 74473 \qquad \ddot{a}_{65}^{(12)} = 9.194$$

Calculate the increase in the normal cost due to the plan amendment.

- (A) 92
- (B) 116
- (C) 153
- (D) 208
- (E) 361

29. Given the following mortality rates for two lives – life x and life y :

t	$q_x(t)$	$q_y(t)$
1	0.10	0.06
2	0.15	0.07

Calculate the probability of the second death occurring during year 2 given that at least one life is alive at the beginning of year two.

- (A) .011
- (B) .024
- (C) .030
- (D) .210
- (E) .220

30-36. Each of questions 30 through 36 consist of an assertion in the left-hand column and a reason in the right-hand column. Code your answer to each question by blackening space:

- (A) If both the assertion and the reason are true statements, and the reason is a correct explanation of the assertion.
- (B) If both the assertion and the reason are true statements, but the reason is NOT a correct explanation of the assertion.
- (C) If the assertion is a true statement, but the reason is a false statement.
- (D) If the assertion is a false statement, but the reason is a true statement.
- (E) If both the assertion and the reason are false statements.

ASSERTION

REASON

30. In Canada, charitable contributions were changed from tax deductions to tax credits.

BECAUSE

A tax credit has a more progressive tax effect than a tax deduction.

ASSERTION

REASON

31. For accumulation annuities, surrender charges are the most important source of profits.

BECAUSE

Most accumulation annuities end in surrender.

ASSERTION

REASON

32. Accident medical expense policies are the most common form of single trip policies.

BECAUSE

The price for single trip accident medical expense coverage is small relative to other available coverages providing similar benefits.

	<u>ASSERTION</u>		<u>REASON</u>
33.	Under the simplified net premium method, higher reserves are produced by including the acquisition expense.	BECAUSE	Under the simplified net premium method, the net premium is calculated to cover both death benefits and the initial expense.
	<u>ASSERTION</u>		<u>REASON</u>
34.	Relevant cost pricing is more profitable than full cost pricing.	BECAUSE	In relevant cost pricing, costs are determined after prices are projected.
	<u>ASSERTION</u>		<u>REASON</u>
35.	Large group life claim experience tends to be relatively volatile.	BECAUSE	Claim experience for large group life insurance has a wide variation in amounts.
	<u>ASSERTION</u>		<u>REASON</u>
36.	Insurers are moving towards an own occupation definition of disability in individual disability income policies sold to white collar and professional people.	BECAUSE	In individual disability income, the own occupation definition results in a more subjective insurance risk.

37-41. Each of questions 37 through 41 consist of two lists. In the list at the left are two items, lettered X and Y. In the list at the right are three items, numbered I, II, and III. ONE of the lettered items is related in some way to EXACTLY TWO of the numbered items. Indicate the related items using the following answer code:

	<u>Lettered Item</u>	<u>Is Related to Numbered Items</u>
(A)	X	I and II only
(B)	X	II and III only
(C)	Y	I and II only
(D)	Y	I and III only
(E)	The correct answer is not given by (A), (B), (C) or (D).	

37. X. No-fault liability insurance I. Workers compensation is an example.

Y. At-fault liability insurance II. The total premium is usually lower.

III. Medical payments coverage is usually compulsory.

38. X. Type of compensation for hospitals I. Per diems

Y. Type of compensation for physicians II. Fixed fee schedule

III. Diagnosis related groupings

- 39.** X. Earnings reserves I. In the U.S., best estimate assumptions with provisions for adverse deviations are used.
- Y. Solvency reserves II. Impact amount of capital invested.
- III. Create new business strain.
-
- 40.** X. Arguments for state regulation I. Workability
- Y. Arguments for federal regulation II. Flexibility
- III. Effectiveness
-
- 41.** X. Pay-as-you-go Old-Age Security Plan I. Typical for public defined benefit plans.
- Y. Fully-funded Old-Age Security Plan II. Investment earnings help pay for future benefits.
- III. Cheaper in early years of plan.

42. Rank in ascending order (from smallest to largest) the actuarial liability for a final salary pension plan under the following methods:

- I. Traditional unit credit method at age x .
- II. Projected unit credit method at age x .
- III. Entry age normal at age x .

- (A) I < II < III
- (B) I < III < II
- (C) II < III < I
- (D) III < I < II
- (E) III < II < I

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

**Society of Actuaries
Course 5**

Application of Basic Actuarial Principles

Afternoon Session

SECTION C - WRITTEN ANSWER

Question 8

(5 points) Describe the factors which affect the laps rate on insurance policies.

Question 9

(7 points) Describe the methods available to develop claim reserves for group insurance products and explain when each would be appropriate.

Question 10

(4 points) John is 30 years old and has been working 5 years for Company A which did not have a pension plan. His company is going to adopt a pension plan. He is now also considering a new position with two other companies.

Company A provides a salary with 2% annual increases. The pension benefit is 2% of the employee average salary during the last 5 years of service times the number of years of service. They will recognize in the pension formula the 5 years previously worked. There is no penalty if an employee retires before age 60.

Company B offers a starting salary 20% higher than Company A with 2% annual increases. The pension benefit is 2% of the employee average salary during the last 3 years of service times the number of years of service. They offer no recognition of past work. There is no penalty if an employee retires before age 60.

Company C offers a starting salary 45% higher than Company A with 2% annual increases. The pension benefit is 2% of the employee final salary times the number of years of service. They offer no recognition of past work. Furthermore, there is a 2% penalty per year if an employee retires before age 60.

Compare each offer based on the pension benefit John would receive if he retires at age 55. Show all work and calculations.

Question 11

(4 points) With respect to property and casualty insurance,

- (a) Describe the objectives of ratemaking.
- (b) Describe the components included in the development of rates.

Question 12

(3 points)

- (a) Describe each of the following with respect to the DAC Tax regulations:
- (i) goals of the DAC Tax
 - (ii) how it is applied
 - (iii) the financial impact on the insurance company
 - (iv) factors that affect its application
- (b) A very large U.S. insurance company sells only individual 20-year term life insurance policies. You are given the following information:

Non-qualified policy issue date	September 1, 2002
Face amount	\$1,000,000
Annual premium (for 20 years)	\$1,000
DAC Tax Rate	7.7%
Amortization period	10 years

Calculate the change in company's taxable earnings in 2004.

Show all work and calculations.

Question 13

(6 points)

- (a) Outline the concerns of regulators regarding insurance rates for individual policies.
- (b) Describe the types of regulation on individual life insurance and group life insurance policy forms.

Question 14

(4 points) A life insurance company wishes to offer a 5-year term product through direct marketing.

- (a) Describe the features that could be included in this product.
- (b) Describe the most common direct marketing approaches.

Question 15

(7 points) You are given the following for a pension plan covering one individual.

Pension formula:

$$\begin{aligned} & 2.0\% \times \text{years of participation in plan up to 25 years of service} \\ \text{plus } & 1.5\% \times \text{years of participation in plan in excess of 25 years of service.} \end{aligned}$$

The pension benefit is payable as a life annuity.

Pension valuation date:	1/1/2002
Funding interest rate:	8.0%
Normal retirement age:	65
No termination or death assumed prior to normal retirement age	
Date of birth:	1/1/1952
Date of hire:	1/1/1977
Date of Participation:	1/1/1977
2001 Salary:	\$100,000
Future salary increases:	0%
Present value of \$1 payable for life, starting at age 65:	10
Asset value at 1/1/2002:	\$150,000
Asset value at 12/31/2002:	\$180,000

Calculate the normal cost and the unfunded actuarial liability as of 1/1/2002 under the following cost methods:

- (a) Traditional Unit Credit
- (b) Projected Unit Credit
- (c) Entry Age Normal (level percent of pay)
- (d) Aggregate (level percent of pay)

Show all work and calculations.

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

November 2002 Course 5 Written-Answer Solutions

Question 1 Solution

(a)

Mortality and spouse mortality before retirement and after retirement. If die prior to retirement loss of earnings for spouse. If spouse dies prior to retirement loss of their earnings. If die after retirement, retirement benefits may be decreased.

Investment risk -- If defined contribution plan investment risk is with the policyholder. If defined benefits plan investment risk is with plan holder. Investment returns need to keep pace with inflation and also salary increase.

Disability Risk -- If become disabled before retirement, there could be expenses related to disability. Typically a loss of income. Accrual of future pension benefits may not occur. Disability insurance could quit paying at 65.

Inflation Risk -- Cost to maintain same standard of living as preretirement is greater. Investment returns must keep pace with inflation both prior to retirement and after retirement.

Longevity Risk -- Risk that employee will live past the use of their funds.

Tax change risk -- If there are changes in the tax laws after tax income may be different than projected. Could result in increase or decrease of net retirement.

Medical Expense Risk -- If great medical needs then could eat at retirement income.

Salary Increase Risk Prior to Retirement -- Salary increase risks involves salary increasing faster than projected. Defined contribution plans may not be able to keep pace. Defined benefit plans based on final average salary can reduce the risk.

(b)

Inflation risks can be addressed by using cost of living adjustments or ad hoc adjustments after retirement. Retirement benefits could be based on Final Average Salary to combat inflation during working years. Could also increase unit benefits, fixed benefits, and flex benefits to keep pace with inflation prior to retirement. For DC plans, offer increasing annuity options for defined contributions participants at retirement.

Longevity risk -- For defined contributions plans can help to determine how much can be spent each year. Can offer certain and life or life only annuity options on retirement.

Tax change risk -- There isn't much that can be done to minimize this risk. Higher before tax and retirement increases could help if tax rates increase.

Medical Expense risk -- Provide retirees with retirement medical benefits supplements to medicare.

Salary Increase risks -- This risk is best minimized by using a final average salary formula for retirement benefits.

Mortality risks -- Can provide survivor income benefits or death if employee dies prior to retirement or after retirement. If retirement benefit is a lump-sum at retirement, then the employee dying after retirement will have little effect. Less money is needed for one person to survive than two.

Investment Risk -- Can be placed in hands of individual with retired contribution plan or can be in hands of employer with defined benefit plan. Either way the best way to reduce investment risk is to diversify funds. Could offer hybrid plans that include both defined contribution and defined benefit like a cash balance plan.

Disability Risk -- Can provide unreduced pension benefits if disabled. Provide long-term disability insurance as well as retirement plan. Could continue to fund plan without penalizing for disability.

Question 2 Solution

(a) Feasibility of developing fixed premium UL:

Regulatory barriers -- Company needs to look at reporting, taxation, accounting, licensing requirements for this product.

Implementation barriers -- The admin system may need to be changed or new one created to handle fixed premium UL. If this product is very different from existing products, company would need to train employees and agents.

Product and company fit -- Need to see if fixed premium UL product fits with company strategy, goals, mission, vision, culture, target markets, core competencies, and distribution channels.

Effects on existing products:

1. Take away sales from existing company product.
2. Replace existing company product.
3. Upgrade current customers to new UL product.
4. Current customers with agents surrender old product and either purchase new UL product or go elsewhere since you didn't give them an upgrade.

(b) Issues involved in fixed premium UL design:

Company wants a high fixed premium to ensure that the policy will stay in force for a certain amount of time. That way you can recoup acquisition costs.

Policyholder wants a low fixed premium. So company needs to balance those two issues.

May also want to minimize or maximize cash value of the fixed premium UL product.

The interest rate credited should be chosen to balance the competitiveness of the product and policyholder disappointment.

Expenses to consider are recreating calculations, lapses and reinstatements processing, fixing past mistakes, and segmenting assets.

(c) Pricing pitfalls

Inappropriate pricing assumptions:

1. Using best guess assumptions for key assumptions.
2. Not reflecting that you're targeting new target market or using new distribution system.
3. Not accounting for rational buyer behavior.
4. Allowing first year commissions plus cash value exceed first year premium.
5. Counting on high lapses during low cash value times to meet profit objectives.
6. Subsidizing high profile cells with other cells.
7. Not fully understanding cost of options (example: surrender at book value)

Misunderstanding the environment:

1. Not appropriately modeling accounting, reserving, required capital, and taxation requirements.
2. Using accounting depreciation instead of market value.
3. Not accurately reflecting timing of cash flows.
4. Using terminals reserves rather than more conservative mean reserves (more of a problem for term insurance).

Technical mistakes:

1. Including interest on past profits.
2. Discounting profits at too low of a rate.
3. Discounting losses at too high of a rate (should use borrowing rate).

Question 3 Solution

(a)

(i) Case Reserves Plus

When an adjuster is assigned to a claim, he or she creates a claim file and calculates an estimated loss reserve to hold for that claim. The loss reserve represents the expected ultimate claim payment. The adjuster takes into account the following:

- Severity of the loss.
- Estimated time until final payment
- Inflation from current time until time of each payment.
- Recent trends in claim payments.
- Any other pertinent information.

The aggregate of these case file reserves is referred to as “case reserves”.

The Case Reserves plus method uses these case reserves plus an additional reserve called “Gross IBNR” reserves. Gross IBNR reserves hold provisions for the following:

- Future development in known claims.
- IBNR (incurred but not reported) claims.
- RBNR (reported but not recorded) claims.
- Closed claims that may reopen.

The problem with this method is that companies in the past have used the Gross IBNR as a year-end balancing item and in some cases, this led to insolvency.

(ii) Expected Loss Ratio:

Uses

- Might be the only method that can be used for new business.
- Good to see if another method is reasonable.
- Government might require minimum loss ratio.

Problems

- Expected loss ratio is subject to manipulation.
- Can give unrealistic results.

Estimated Ultimate Losses = Earned Premium x Expected Loss Ratio

Estimated Reserve = Estimated Ultimate Losses - (Losses Paid-to-Date)

(iii) Bornhuetter- Ferguson

- Blend of chain ladder method and expected loss ratio method.
- More stable than chain ladder.
- Need external data to get expected loss ratio.
- Estimated Ultimate Losses = Earned Premium x Expected Loss Ratio

$$\text{Expected Reserve} = (\text{Estimated Ultimate Losses}) \left(1 - \frac{1}{pf_j} \right)$$

Estimated ultimate losses = Earned Premium × Expected Loss Ratio

Estimated reserve = Estimated Ultimate Losses - (Losses Paid - to - date)

$$f_j = \text{link ratio} = \frac{\text{Cumulative paid claims}(t)}{\text{Cumulative paid claims}(t-1)}$$

(b)

Assuming the chain ladder method

Expected Ultimate Incurred Losses = (Losses Paid-to-date) $\prod f_j$

$$f_j = \text{link ratio} = \frac{\text{Cumulative claims}(t)}{\text{Cumulative claims}(t-1)}$$

Using average method to calculate the link ratios

Accident Year	1/0	2/1	3/2	4/3	5/4
1998	$\frac{5843}{4869} = 1.2$	1.107	1.04	1.02	1 (given)
1999	1.23995	1.11	1.03		
2000	1.16998	1.09			
2001	1.21996				
AVG	1.207	1.102	1.05	1.02	

$$1.207 = \frac{1.2 + 1.23995 + 1.16998 + 1.21996}{4}$$

Expected Ultimate losses for 2000: $10,841 \times (1.035)(1.02) = 11,444.84$

Expected Ultimate losses for 2001: $12,557 \times (1.102)(1.035)(1.02) = 14,608.58$

Could have used a weighted average link ratio.

For 1/0, the ratio would be $\frac{5843 + 8175 + 9946 + 12557}{4869 + 6593 + 8501 + 10293} = 1.207$

For 2/1 1.10098

E(Ultimate Losses 2000) = 11,436

For 3/2 1.0342

E(Ultimate Losses for 2001) = 14,583,78

For 4/3 1.02

Assuming that the far right diagonal is not quite complete since the data are as of 9/30/2002:

We could adjust the values by multiplying by $\frac{4}{3}$, if this is uniformly distributed during the year. 1998 accident year claims at duration 4 would be as follows if we adjust.

$$6861 - 6727 \left(\frac{4}{3} \right) + 6727 = 6905.67$$

This would change the link ratios as well as the expected ultimate losses.

Question 4 Solution

(a)

(i) Heaped

Large first year commission followed by much smaller commissions in renewal years in a deceased pattern over time.

(ii) Levelized

First year commission smaller than heaped renewal year commissions, larger than heaped.

(iii) Level

Equal commissions in all early years

Example (commissions as a percent of premium)

Policy Yr	Heaped	Levelized	Level
1	55%	20%	15%
2	5%	15%	15%
3	5%	15%	15%
4	5%	12%	15%
5	5%	12%	15%
6	5%	5%	15%
7	5%	5%	15%
8	5%	5%	15%
9	5%	5%	15%
10	5%	5%	15%
11+	5%	5%	5%

(b)

Issues when adopting levelized or level commission structure

- Will emerging experience differ from pricing experience (persistency should increase)? Will mortality change?
- What will the impact be on agent retention/recruiting?
- Will agents become vested in new commissions, then leave to sell for a company which still heaps?
- Will the switch be permanent or temporary?
- Will there be a greater need to subsidize the costs of newer agents?
- Give agents a choice?
- Recalculate commissions retroactively, or just use new system going forward? Retroactively could win agents due to the new scheme.
- How will agency development costs be affected?
- Lower up front commission may result in increased agency subsidies.
- If commissions are disclosed, will level/levelized commissions increase customer approval?

Question 5 Solution

(a)

(i) Embedded Value = \sum PV Profits at hurdle rate

$$= \frac{150}{1.1} + \frac{250}{1.1^2} + \frac{300}{1.1^3} + \frac{500}{1.1^4} + \frac{800}{1.1^5} = 1406.61$$

(ii) Return on Assets (ROA) = $\frac{\text{PVF Profits}}{\text{PVF Assets at after tax interest rate}}$

$$\text{PVF Profits} = \frac{150}{1.05} + \frac{250}{1.05^2} + \frac{300}{1.05^3} + \frac{500}{1.05^4} + \frac{800}{1.05^5} = 1666.94$$

$$\text{PVF Assets} = \frac{600}{1.05} + \frac{1200}{1.05^2} + \frac{1800}{1.05^3} + \frac{900}{1.05^4} + \frac{0}{1.05^5} = 3955.20$$

$$\text{ROA} = 1666.94 / 3955.2 = 42.15\%$$

(iii) Accumulated profit as percent of reserve at end of year 3.

$$150(1.05)^2 + 250(1.05) + 300 = 727.875$$

$$\text{Reserve at } t=3 = 1800$$

$$\text{Accumulated profit as percent of reserve at end of year 3} = \frac{727.875}{1800} = 40.44\%$$

(b)

Other profit measures

ROI= Return on Investment

- Solve for i such that $\sum \text{PVF Profits} = 0$
- Calculations can blow up if all future profits are positive.
(no solution)
- Can yield multiple results

$$\text{Profit as a percent of Premium} = \frac{\text{PVF Profits}}{\text{PVF Premium}}$$

$$\text{Profit as a percent of Revenue} = \frac{\text{PVF Profits}}{\text{PVF Revenue}}$$

- Definition of revenue varies by product.

$$\text{Profit as a percent of Risk Charges} = \frac{\text{PVF Profits}}{\text{PV Risk Charges}}$$

- Compare profit directly to risk charges
- Risk charges are often arbitrary, difficult to calculate.

Breakeven year -- year in which accumulated profits turn positive and stay positive.

- More of a warning sign than a profit measure
- Too risky if too long, meaning holding capital too long.

$$\text{New Business Strain} = \frac{\text{Distibutable earnings in year 1}}{\text{Premium in year 1}}$$

$$\text{Weighted Average Return on Equity} = \frac{\text{PVF (after tax shareholder earnings)}}{\text{PV (Equity Base)}}$$

Question 6 Solution

(a)

1. Cultural differences -- suicide, violence
2. Location differences
3. Underwriting differences -- more rigid requirements leads to lower mortality
 - Medical -- doctor exam
 - Para medical -- few questions of exam by nurse
 - Non medical -- no of few questions
 - Agent -- relies on agent; may have high mortality lower if captive agent
4. Availability, cost and access of medical, hospital, other services
 - Includes preventive care
5. Personal risk factors -- age, gender, education level, wealth, occupation, smoker, non smoker
 - Females have lower
 - Higher education lower, wealthy lower; correlation with education
 - Smokers have higher mortality
6. Environmental Risk Factors
 - Famine, cost of living, etc., standards of living
7. Wars, natural disasters
 - More mortality
8. General variation
 - Age
 - Sex
 - Selective lapse
 - Occupation
 - Disability -- higher
 - Policy size -- lower mortality for larger size, except at real high amounts
9. Antiselection at time of underwriting -- underwriting criteria could be selected against
10. Lapse variations
11. Pricing changes in premium
 - large increases could lead to selective lapses
 - good risk...healthy lives will leave for cheap plans
 - bad risk will remain
12. Selective Lapse
 - Assume overall deaths remain same

$$q_w sel = sel \% q_w extra$$

$$q_w extra = q_w sel + q_w non sel$$

- Set dates equal before and after

$$\left[1 - q_w norm \right] q_w norm = \left[1 - q_w norm - q_w extra \right] q_d Actual + q_w norm q_d norm + q_w sel q_d sel$$

- Solve for new $q_d Actual$

- Will be higher than q_d norm if selective lapse had higher mortality

13. Effect of lying

- Dramatic effect on mortality if lied
- Monitor experience, could be just a few agents
- Could use experience rating
- Or retroactive underwriting
- Could void coverage

(b)

Industry trend to increase # of risk factors.

- May need new class to stay competitive.
- May attract good risk from competitor

Effect of stratification

- Will interact with competitors dividing line
- Higher mortality is at the line, the higher mortality 60+ above and below the line
- Will attract customers from competition that just qualify for preferred class... higher mortality.
- Will lose customers who just miss qualifying if can get better rate.

Other considerations on new preferred class.

- Those who qualify for best class buy more
- Higher placement for best class.
- Higher average size.
- Less lapse...greater persistency for higher class; think they got good deal

Consider costs of establishing new class

- New administrative, new underwriting criteria
- Must file to get approved
- Will be expensive to remove class if later decide.

Consider effects of selective lapses

- May change mortality
 - Could improve, but somewhat unknown
 - Needs to be researched

Question 7 Solution

- Death benefits are received tax free.
- Premiums for life insurance are not tax deductible.
- Dividends will be taxed on surrender if CSV exceeds adjusted cost basis.
- Inside build up escapes current taxation if policy is not surrendered
- However, policy is taxed on surrender of policy
- Tax will be excess of the CSV over the policyholder's net cost
- The net cost is the sum of premiums less any dividends
- In Canada only, the net cost is reduced by the cost of pure insurance protection
- Policyholder can exchange under certain conditions or policies in the U.S. without incurring any tax
- Canada does not permit tax free exchanges
- In the U.S., receipt of a policy loan is a non-taxable event
- In Canada, proceeds of a policy loan are surrender benefits and will be taxed to the extent loan exceeds the net cost
- In both countries, policy loan interest is not tax deductible
- In Canada, policies with high investment component are taxed like deferred annuities. In the U.S., they are treated like a taxable savings account at term insurance.
- Modified endowment contracts are only in the U.S. and receive tax free death benefits that build up, but policy loans are treated as distributions and are taxed as an "increase comes out" first basis.

Question 8 Solution

Ability to pay -- if the customer has more disposable income, then less likely to lapse

Customers attitude to the product -- if the customer views product as fulfilling important financial need, then less likely to lapse.

Agent's attitude toward persistency -- the agent may try to replace the product for new first year commissions.

Everyone perceives the value differently -- the more it is valued, the less it will lapse.

Maybe policies sold differently -- if customer was pressured to buy, then more likely to lapse.

Degree of understanding -- if the value is understood, then less likely to lapse.

Ease of premium payments -- if payments are payroll deducted, then less likely to lapse.

By Product

- Permanent products have low lapse rate
- Term product has high lapse rate
- Term to 100 has very low lapse rate

Policy year -- first few years, lapse rate goes down fast, then it declines at a slower rate.

Issue age -- younger issue ages are more prone to lapse.

Policy size -- larger sizes lapse less, unless subject to replacement.

Frequency of premium payments -- more frequently paid premium increases the lapse rate.

Method of premium payments -- if it's a payroll deduction, then less likely to lapse.

Standard vs. nonstandard -- the people in the better class will feel they got a good deal and lapse less.

Risk class -- preferred lapse less than residual.

Gender -- females are less likely to lapse.

Size of premium increases -- high/large premium increases will increase lapses.

Surrender charges -- low surrender charges will increase lapses.

Persistency bonus -- may return COI charges after number of years.
- reduces lapses before that point, but a spike after that point.

Question 9 Solution

Factor Method, Lag or Development or Chain Ladder Method, Tabular Method Average Size Method, Examiners' Method, Loss Ratio Method

Factor Method:

- Establish reserve as a percent of premium based on past experience.
- Unsophisticated method
- Appropriate for products with high frequency, low volatility
- Estimate can be replaced with actual claims experience as available

Lag or Development or Chain Ladder Method

- Not stable because so many variables are involved
- Statistical method
- Assumes future experience patterns will be similar to past experience patterns
- Start by collecting data by incurred and paid periods
 - Need claims data and premium or exposure data
- Best for products with short run-off
 - Can be used for medical claims
- Create a table of cumulative paid claims by incurred and paid periods
- Determine loss development factors based on the cumulative paid data. - - For each incurral period (often in monthly units), determine the percent of claims already completed; at some point, 100% complete will need to be assumed
- The percent of claims already completed for each incurral period is the completion factor
- Estimated Ultimate Incurred Claims
$$= \frac{\text{claims paid to date}}{\text{completion factor}}$$
- Reserve = Estimated Ultimate Incurred Claims – Losses Paid-to-date

Tabular Method -- requires a separate IBNR calculation

- Applies a factor to claims already paid or premiums waived
- Factor may be a disability continuance probability
- Ultimate Incurred Claims = Losses Paid-to-date × Factor
 - or = Premiums waived × Factor
- Appropriate for long-term disability claims
- Reserve = Ultimate Incurred Claims – Losses Paid-to-date
- Reserve = Ultimate Incurred Claims – Premium Waived-to-date

Average Size Method

- Estimate is only as good as the average size value
- Estimated Ultimate Incurred Claims = (Number of Claims) × Average Size
- Requires a separate IBNR calculation to determine the numbers of claims outstanding

- Reserve = Estimated Ultimate Incurred Claims – Claims Paid-to-date
- Appropriate for products with low volatility and high frequency

Examiner's Method

- Unprofessional and unsophisticated
- Requires a separate IBNR calculation
- Claims examiner estimates the amount of claims remaining to be paid for a specific loss event
- Consider timing of payments, estimated settlement amounts, claims that are closed and may reopen, development of current claims
- Appropriate for large losses involving major settlements

Loss Ratio Method

- To be used as a verification of other reserve methods or in the case of a new product when no other information is available
- Requires an expected loss ratio which is subjective and may be manipulated by management
- Ultimate Incurred Claims = Loss Ratio × Premium
- Reserve = Ultimate Incurred Claims – Losses Paid-to-date

Question 10 Solution

Company "A" is offering pension benefit based on EAN method with average salary of last five years

$$\text{Pension Benefit} = (r - e) \times S_r \times \text{Discount Factor} \times \text{Annuity Factor}$$

$$\text{Salary at Retirement} = \text{Salary Now} \times \left[\frac{1.02^{r-x-1} + 1.02^{r-x-2} + \dots + 1.02^{r-x-5}}{5} \right]$$

$$\begin{aligned} \text{Salary}_{55} &= S_x \times \left[\frac{1.02^{54-x} + 1.02^{53-x} + 1.02^{52-x} + 1.02^{51-x} + 1.02^{50-x}}{5} \right] \\ &= S_x \times 1.54658 \end{aligned}$$

Under Company B

$$\text{Salary}_{55} = 1.2 \times S_x \times 1.02^{-3x} \left[\frac{1.02^{54-x} + \dots + 1.02^{52-x}}{3} \right] = 1.892526 \times S_x$$

Under Company C

$$\text{Salary}_{55} = S_x \times 1.45 \times 1.02^{54-x} = 2.3322 \times S_x$$

Pension Benefits

Under Company A

$$\text{PB} = 0.02 \times 30 \times S_x \times 1.54658 = 0.92795 \times S_x$$

Under Company B

$$\text{PB} = 0.02 \times 25 \times S_x \times 1.892526 = 0.94626 \times S_x$$

Under Company C

$$\text{PB} = 0.02 \times 25 \times 0.9 \times 2.3322 \times S_x = 1.04950 \times S_x$$

Best offer is given by Company "C"

Next best offer is given by Company "B"

Least best offer is given by Company "A"

Question 11 Solution

(a)

Essential Objective

- 1) Cover expected loss and expense
 - It should avoid inter-generation subsidies. Each cohort of policyholders should pay for their own benefits and expense.
 - If selling a product creates a loss, it must fund with surplus of the company rather than rob other policyholder groups.
- 2) Provide rates that make adequate provisions for contingency.
 - Competition is fierce and policyholder can choose options of self-insured, so difficult to provide adequate rates.
 - Inadequate rates hurt profit and increase company insolvency risk.
- 3) Encourage loss control
 - Provide incentive to policyholder about the relationship of lower rates and lower losses.
 - Goals are to keep rate low and reduce accidents.
- 4) Satisfy Rate Regulators
 - Should produce rates that are adequate, not excessive and not unfairly discriminatory.
 - Actuary should defend rate change. Rate change should be done based on general accepted actuarial techniques since results will be cross-checked.
 - Actuary should also defend variables like marriage which sounds socially unacceptable.
 - Sometimes regulators want to make rates "affordable" so they can elect changes.

Non-essential but Desirable Objective

- 1) Produce rates that are reasonably stable
 - Policyholders prefer rates that are not volatile. Reinsurance can help to smooth rates.
 - 2) Produce rates that are reasonably responsive to change.
 - Should take a balance with "stability"
 - 3) Simple and easy to understand.
- Should be easy for non-technical agents, rate regulators, and senior management to understand.

(b)

Loss-development Factors

- Data is incomplete if use accident's year or policy year.
- It is needed to estimate the claim reserve.
- Loss-development factors are applied to loss (either paid loss or incurred loss) to calculate the ultimate loss for each accident's year.

Trend Factors

- To increase the loss to keep pace with events like inflation.
- Can use least-square regression method to find the growth rate and project the loss.
- Projection is from middle of exposure period to middle of projection period.

Fully-development and trended loss

$$= (\text{Loss Paid-to-date}) \times (\text{Loss} - \text{Development Factors}) \times (\text{Trended Factors})$$

Expense

- Divided into two categories

1) Loss adjustment expense (LAE)

- Expense incurred when claim is incurred (e.g., lawyer's fee)
- Treated like claim
- Can be allocated or unallocated

2) Others (e.g., commission)

- Can be variable or fixed

$$\text{Gross premium rate} = \frac{\text{Loss Incurred}}{\text{Loss Permissible Ratio}}$$

Where loss permissible ratio = 1 - (% of expense that are not LAE)

Provision for contingency or profits

- Can be implicitly added or explicitly added.
- If implicitly added, can assume zero investment income.
- Or can explicitly add a profit loading or contingency loading

Credibility

- Need certain amount of data to be credible so that we can calculate rates using past loss experience.

Investment Income

Question 12 Solution

(a)

- Increase taxes paid to government
- Just a timing difference, so like an interest free loan to government. (lost investment income).
- Applied as a % of premium.
- Increases taxable income in the first year a premium is paid and reduces taxable income for the premium payment over the rest of the amortization period.
- % varies by product type
- amortization period varies by size of company

(b)

- Dac Tax Amount (t) = Dac Tax Pct \times Prem (t)
+ Dac tax Pct \times Prem(t) \times (-5%)
+ Dac Tax Pct \times S (r from 1-9) Prem (t + r) \times 10%
+ Dac Tax Pct \times Prem (t-10) \times (-5%)
- Dac Tax Amount = $1000 \times (7.7\%) - 1000 \times (7.7\%) \times 5\%$ 2004 prem.
- $1000 \times (7.7\%) \times 10\%$ 2003 prem
- $1000 \times (7.7\%) \times 10\%$ 2002 prem
= $75\% \times (1000) \times 7.7\% = \57.75

Question 13 Solution

(a)

Want to avoid excessive rates – this is somewhat controlled by competition or minimum loss ratios.

Want to avoid inadequate rates – concerned about insurance company solvency
Mandate reserve requirements indirectly influence premium levels to ensure adequacy of rate. Minimum reserves mean higher asset requirements raising necessary premiums.

Avoid unfairly discriminatory rates
Cannot charge different rate for different people in the same class of insureds. For individual insurance, rate distinction by sex is generally acceptable (except in Montana) but sex-blended mortality is used for employer-sponsored plans. The commissioner will investigate for unfairly discriminatory rates (by race, religion, etc.).

There are statutory provisions prohibiting unfair trade practices.

Want to avoid price fixing and formation of monopolies.

May require a buying guide or policy summary to help purchasers.

May limit first year commissions.

If an illustration is used in the sale, it must be an approved illustration using a disciplined current scale.

(b)

There are standard provisions required in the form:
Entire contract clause, incontestability clause, reinstatement provision, settlement options, grace period, etc.

Some states may impose other necessary provisions or mandatory benefits.

The policy form must meet the requirements of all states otherwise will need state-specific forms.

Policies may include nonforfeiture provisions for lapse or surrender of the policy. May include a dash surrender option or a reduced paid-up insurance benefit.
Surrender values calculated independent of policy reserves
Surrender values should reflect asset shares.

Policy forms need to be filed with state of domicile and all marketed states for approval.

Usually states require approval before sales occur, but if no response in a required amount of time may be deemed approved. If form is used before formal approval is received, must withdraw and cease sales if later disapproved. Some states may require state of domicile approval before filing in their state.

If the policy is found to be deceptive the commissioner can disapprove the policy.

If the policy's provisions are more favorable than the minimum requirements, that is acceptable.

Some states may require an actuarial memorandum to be filed with the form.

If a variable product, will also require SEC approval.

Question 14 Solution

(a)

Product should:

- Require only limited underwriting
- Have little or no cash value

Renewable

- Continue insurance at the end of the 5-year period
- Premium will be higher

Convertible

- Right to purchase permanent coverage
- Within certain number of years

Re-entry

- Get lower renewal rate
- By passing underwriting again

Indeterminate premiums

- Premium guaranteed for first few years only
- Show current and guaranteed maximum premium

Guaranteed upgrade

- Existing clients get benefit of any new features introduced in future

(b)

Generally successful if response rate received is .5% to 1%, which is low for other types of marketing.

Direct Mail

- Mail information to thousands of potential customers

Telemarketing

- Call center thousands of potential customers

Direct Response

- Advertise in public media (TV, radio, magazines)
- Provide toll-free number for interest parties to call

Internet

- Potential customers fill in application on-line

Question 15 Solution

(a)

In pension formula, assuming it is % of pay.

Service at 1/1/2002 = 25 years

TUC

$$B_{50} = (2\%)(25)(100,000) = 50,000$$

$$\begin{aligned} AL_{50} &= B_{55} - \ddot{a}_{65}^{(12)} \times \frac{D_{65}}{D_{55}} - V^{15} \\ &= (50,000)(10)(1) \left(\frac{1}{1.08} \right)^{15} \\ &= 157,620.85 \end{aligned}$$

$$UAL = AL_{55} - \text{Asset} = 157,620.85 - 150,000 = 7620.85$$

$$\begin{aligned} NC &= (0.015)(100,000) \times \ddot{a}_{65}^{(10)} \left(\frac{D_{65}}{D_{55}} \right) V^{15} \\ &= (0.015)(100,000) \times (10)(1) \times \left(\frac{1}{1.08} \right)^{15} = 4728.63 \end{aligned}$$

(b)

Projected Unit Credit

Since no future salary increase assumed, PUC has the same result as TUC.

(c)

Future salary increase = 0%

Assuming past salary increase also 0%

Level percent of pay equals to level dollar amount.

$$NC \ddot{a}_{25:40} = PVB \text{ at entry age}$$

$$PVB_E = B_{65} \times V^{40} \ddot{A}_{65}^{(12)} \times \frac{D_{65}}{D_{25}}$$

$$B_{65} = (0.02 \times 25 + 0.015 \times 15) \times 100,000 = 72,500$$

$$PVB_E = 72,500 \times 10 \times \left(\frac{1}{1.08}\right)^{40} \times 1 = 33,372.43$$

$$\ddot{a}_{25:40} = \frac{1 - V^{40}}{1 - V} = \frac{1 - \left(\frac{1}{1.08}\right)^{40}}{1 - \frac{1}{1.08}} = 12.879$$

$$NC = \frac{33,372.43}{12.879} = 2591.31$$

$$AL_{50} = PVB_{50} - PVFNC$$

$$PVB_{50} = (0.02 \times 25 + 0.015 \times 15) \times 100,000 \times 10 \times \left(\frac{1}{1.08}\right)^{50} = 228,550.23$$

$$PVFNC_{50} = NC \times \ddot{a}_{50:15} = 2591.31 \times \frac{1 - \left(\frac{1}{1.08}\right)^{15}}{1 - \frac{1}{1.08}} = 23,954.68$$

$$\text{note: } \frac{1 - \left(\frac{1}{1.08}\right)^{15}}{1 - \frac{1}{1.08}} = 9.2442$$

$$AL_{50} = 228,550.23 - 23,954.68 = 204,595.55$$

$$VAL = 204,595.55 - 150,000 = 54,595.55$$

(d)

Aggregate:

$$NC \times \ddot{a}_{50:15} \text{ PVB} - \text{ASSET}$$

$$\text{PVB} = \frac{(0.02 \times 25 + 0.015 \times 15) \times 100,000}{B_{65}} \times 10 \times 1 \times V^{15}$$

$$= 228,550.23$$

$$\text{note: } \ddot{a}_{65} = 10, \frac{D_{65}}{D_{55}} = 1, V^{15} = (1.08)^{-15}$$

$$\ddot{a}_{50:15} = \frac{1 - \left(\frac{1}{1.08}\right)^{15}}{1 - \frac{1}{1.08}} = 9.2442$$

$$NC = \frac{228,550.23 - 150,000}{9.2442} = 8497.21$$

No AL is calculated under aggregate method

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

FALL 2003
COURSE 5
ANSWER KEY

- | | |
|---------|-------|
| 1. B | 26. D |
| 2. B | 27. B |
| 3. A | 28. C |
| 4. E | 29. B |
| 5. E | 30. A |
| 6. E | 31. D |
| 7. B | 32. C |
| 8. B | 33. D |
| 9. B | 34. A |
| 10. C | 35. A |
| 11. C | 36. B |
| 12. B | 37. A |
| 13. A | 38. E |
| 14. A | 39. E |
| 15. A | 40. A |
| 16. E | 41. E |
| 17. A&B | 42. A |
| 18. D | |
| 19. D | |
| 20. C | |
| 21. E | |
| 22. B | |
| 23. C | |
| 24. D | |
| 25. D | |