# INSTITUTE OF ACTUARIES OF INDIA

# EXAMINATIONS

## 15th May 2008

## Subject CT5 – General Insurance, Life and Health Contingencies

### Time allowed: Three Hours (10.00 – 13.00 Hrs)

### Total Marks: 100

*INSTRUCTIONS TO THE CANDIDATES*

1) *Do not write your name anywhere on the answer sheets. You have only to write your Candidate's Number on each answer sheet/s.*

2) *Mark allocations are shown in brackets.*

3) *Attempt all questions, beginning your answer to each question on a separate sheet. However, answers to objective type questions could be written on the same sheet.*

4) *Fasten your answer sheet/s together in numerical order of questions. This, you may complete immediately after expiry of the examination time.*

5) *In addition to this paper you should have available graph paper, Actuarial Tables and an electronic calculator.*

**Professional Conduct:**

*"It is brought to your notice that in accordance with provisions contained in the Professional Conduct Standards, If any candidate is found copying or involved in any other form of malpractice, during or in connection with the examination, Disciplinary action will be taken against the candidate which may include expulsion or suspension from the membership of IAI."*

**Candidates are advised that a reasonable standard of handwriting legibility is expected by the examiners and that candidates may be penalized if undue effort is required by the examiners to interpret scripts.**

| AT THE END OF THE EXAMINATION |
| --- |
| **Please return your answer sheet/s and this question paper to the supervisor separately.** |

**Q. 1)**    i. List the cash flows involved in profit testing a regular premium term assurance contract by giving the sign of the cash flow ("+" for income and "-" for the outgo to the Company).                                                                                           (3)

ii. Define and explain the following terms:
- Profit Vector
- Profit Signature
- Net present Value of Profit
- Profit Margin                                                                                                        (4)

**[7]**

**Q. 2)**    Find $l_x$, if $\mu_x = \dfrac{1}{(100 - x)}$

**[5]**

**Q. 3)**    A life office issues an annuity to a woman aged 65 exact and a man aged 68 exact. The annuity of Rs.20,000 pa is payable annually in arrears for as long as either of the lives is alive.

The office values this benefit using the following basis:
Interest:         4% per annum
Mortality:    Female:        PFA92C20
                    Male:            PMA92C20

i.   Calculate the expected present value of this benefit.                                        (2)

ii.  Calculate the probability that the life office makes a profit in this case if it charges a single premium of Rs.320,000.                                                               (4)

**[6]**

**Q. 4)**    i. Under what circumstances the non unit reserve is required to be set up in a unit linked contract. Explains how reserving bases affects the profitability of a life insurance contract?                                                                             (3)

ii. If inforce expected net cash flows of a single premium 5 year life insurance contract are (-300, -200, 1000, -400, 200). Calculate the reserves required at the beginning of each of the second, third, fourth and fifth policy year and give the revised profit vector allowing for the reserves.

Assume that reserves earn interest at a rate of 6% per annum and the regulations do not allow negative reserves. You may ignore mortality.                      (5)

**[8]**

**Q. 5)** You are a pricing actuary profit testing a unit linked product with the following features:

- The sum assured plus unit account value is payable on death. Sum assured is Rs.500, 000 in the first year which reduces by Rs.100, 000 at the end of each year.
- The unit account value is payable on maturity.
- The unit account value less surrender charge is payable on surrender.
- The policy term and premium payable term is 3 years and all premiums are payable on annual basis i.e. at the beginning of every year.

The Company will offer two the customers to choose either of the following two charging structures:

| Charge | Charge Structure A | Charge Structure B |
|---|---|---|
| Allocation rate (% of premiums invested into unit account) | 80% of first year premium and 101% of each subsequent premium | 94% of all premiums |
| Bid offer spread | 5% | 5% |
| Surrender Charge | NIL | 15% of outstanding premiums |
| Fund management charge | 1% per annum | 1% per annum |
| Mortality Charge | Nil | Nil |

Following profit test assumptions are given to you.
- Expenses: Rs.2,000 at the start of the first policy year and Rs. 500 at the start of subsequent policy years;
- Commission: 10% of first year premium
- Dependant Rate of Mortality: 0.001 per annum for all ages
- Dependant Rate of Surrender: 0.15 for first year and 0.10 for second policy year
- Unit Growth Rate: 10% per annum
- Interest rate on non unit cash flows: 6% per annum

You may further assume that;
- Expenses (excludes commission), death claims and surrenders occur at the end of the year
- The Fund management Charge for a year is deducted at the end of the year
- The investment return on the unit account is credited at the end of the year
- The interest income on non unit cash flows is earned at the end of the year
- Non unit reserve is zero at the end of each year

a) Calculate the unit account value payable to the policyholder in respect of both the charge structures at the end of the three year period if the annual premium is Rs.100,000. (5)

b) Which charge structure is more profitable to the Company assuming risk discount rate of 10% per annum? (5)

c) Comment on the capital need of the two charge structures under this product (2)

**[12]**

**Q. 6)** A 2-year term assurance policy is issued to a life aged x. the benefit amount is 100 if he life dies in the first year, and 200 if the life dies in the second year. Benefits are payable at the end of the year of death.

    i.     Write down an expression for the present value random variable for this benefit. (2)

    ii.    Calculate the standard deviation of the present value random variable assuming that $q_x = 0.025$, $q_{x+1} = 0.030$ and $i = 0.06$ (4)

**[6]**

**Q. 7)** Explain how the level of education or the type of occupation influences the mortality and morbidity experience of a group of insured lives. **[5]**

**Q. 8)** List the advantages and disadvantages for using single figure indices to measure the mortality rates. **[3]**

**Q. 9)** A male life aged 63 years exact and his spouse aged 60 exact buys a joint life annuity. The contract provides following three benefits:

- Benefit A: an annuity certain of Rs.20, 000 per annum payable monthly in advance during first 10 year of the contract.

- Benefit B: A deferred annuity of Rs.20, 000 per annum payable monthly in advance. This benefit commences immediately after the 10 year expiry period of Benefit A. This benefit is payable as long as both spouse are alive on the due date of the annuity instalment.

- Benefit C: A deferred reversionary annuity of Rs.15, 000 per annum payable monthly in advance. The first annuity installment is payable on the monthiversary following the later of the expiry of the 10 year benefit A period or the death of any one of the two annuitants.

Calculate the single premium for this contract. You should use the following assumptions to calculate the premium:

| Mortality: | PA92C20 mortality tables (as applicable for male and females) |
| Interest Rate: | 4% per annum |
| Expenses: | Policy acquisition expenses of Rs.500 per contract; Maintenance expense of Nil |
| Commission: | 2% of the single premium |

[10]

**Q. 10)** A pension scheme provides retirement benefit payable on ill health retirement only. The benefit is $1/80^{th}$ of final pensionable salary for each compete year of service including the prospective service until age retirement of age 60.

Final pensionable salary is defined as the average of the earnings in the three years immediately preceding the date of retirement. Derive formulae for the evaluation of the present value of the benefit for a new member aged exactly *x*.

Define all functions you use and state clearly all assumptions you make.         [7]

**Q. 11)** Discuss the "Selection Process" in underwriting of cases in life insurance business. How selective withdrawals can affect the mortality experience of a portfolio of life insurance and annuity polices?         [5]

**Q. 12)** A life insurance company issues a 10-year decreasing term assurance benefit to a man aged 50 exact. The death benefit is 100,000 in the first year, 90,000 in the second year and decreases by 10,000 each year so that the benefit in the $10^{th}$ year is 10,000. The death benefit is payable at the end of the year of death.

Level premiums are payable monthly in advance for the term of the policy, ceasing at earlier death.

Calculate the annual premium.

**Basis**

| Interest: | 6% pa |
| Mortality: | AM92 select |
| Initial expenses: | Rs.200 and 25% of total annual premium (all incurred on policy commencement) |
| Renewal expenses: | 2% of each premium from the start of the $2^{nd}$ year and Rs.50 pa, inflating at 1.923% pa, at the start of the second and subsequent policy years. |
| Claim expenses: | Rs.200 inflating at 1.923% pa |
| Inflation: | For the renewal and claim expenses, the amounts quoted are at outset, and the increases due to inflation start immediately. |

[8]

**Q. 13)**   i.   If $P_x$ is the annual premium under a whole life assurance policy to a life aged x, then show that

$$(_tV_x + P_x)\,(1 + i) = {}_{t+1}V_x + q_{x+t}\,(1 - {}_{t+1}V_x)$$

(4)

ii.   Explain the above equation by general reasoning.   (2)

iii.   Explain what is meant by "actual death strain" and "expected death strain".   (2)

iv.   Calculate the profit or loss from mortality for the year to 31$^{st}$ December, 2007. The deferred annuities are payable yearly from the 60$^{th}$ birthday and Sums Assured under the Whole Life policies are paid at the end of the year.

|  | | As at 31.12.07 | | Year 1.1.07 to 31.12.07 |
| --- | --- | --- | --- | --- |
| Class | Age at entry | No. of years in force | Sum Assured or annuity pa | Contracts ceasing by deaths: Sum Assured or annuity pa |
| Whole Life Annual Premium | 30 | 10 | 500,000 | 5,000 |
| Deferred Annuity single premium without return | 40 | 20 | 60,000 | 1,200 |

Basis:

Mortality: AM92 ultimate
Interest:   4% pa

(10)

**[18]**

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