

# INSTITUTE OF ACTUARIES OF INDIA

## EXAMINATIONS

**27th November 2012**

**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** Please read the instructions on the front page of answer booklet and instructions to examinees sent along with hall ticket carefully and follow without exception
- 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** Please check if you have received complete Question Paper and no page is missing. If so, kindly get new set of Question Paper from the Invigilator.

**AT THE END OF THE EXAMINATION**

**Please return your answer book and this question paper to the supervisor separately.**

**Q.1)** (x) and (y) are independent lives both subject to a constant force of mortality of 0.01 per annum. Find the probability that (x) dies first and (y) dies within 10 years after the death of (x). [4]

**Q.2)** (i) Calculate the level annual premium using probability and present value factors, for a 3-year decreasing-cover term policy for a select life aged 43 years exact for an initial sum-assured of Rs 10,00,000. The sum-assured decreases to Rs. 90,000,000 in the second year and to Rs. 80,000,000 in the third year. The premium is payable annually in advance and the death benefit is payable at the end of the policy year of death. Ignore expenses.

Basis:

Interest Rate: 8.25% per annum

$$q_{[x-t]+t} = 0.5 \frac{1}{(t+1)} * q_x \quad \text{for all } x \text{ and } t = 0, 1 \text{ and } 2$$

$$q_{x+1} = 1.10 * q_x \quad \text{and} \quad q_{42} = 0.00232 \quad (6)$$

(ii) What may be the issues with decreasing-cover level premium policies? Suggest two solutions. (2) [8]

**Q.3)** For students entering in a three-year degree course for law school, you are given the following multiple decrement table together with supporting information below

Academic Year	For a student at the beginning of that academic year, probability of		
	Academic Failure	Withdrawal for All Other Reasons	Survival Through Academic Year
1	0.40	0.20	-
2	-	0.30	-
3	-	-	0.60

- Ten times as many students survive year 2 as fail during year 3.
- The number of students who fail during year 2 is 40% of the number of students who survive year 2.

Calculate the probability that a student entering the school will withdraw for reasons other than academic failure before graduation. [6]

**Q.4)** [i] Name the two approximate methods used to compute probabilities involving non-integer ages or duration. (1)

[ii] Prove that  ${}_{t-s}q_{x+s} = \frac{(t-s)q_x}{1-sq_x}$  (4)

[iii] Prove that  ${}_{t-s}p_{x+s} = p_x^{t-s}$  (2)

[iv] Calculate  $0.75q_{75.75}$  using the method used in (ii) above. (4) [11]  
Basis: Mortality ELT15(Males)

- Q.5)** A life insurance company sells term assurance policies with policy terms of either 5 or 10 years.

You have been asked to carry out the review of the mortality experience of these policies. The following table shows the statistical summary of the mortality investigation. In all cases, the central rates of mortality are expressed as rates per 1,000 lives.

Age	All Policies		5 Year Policies		10 Year Policies	
	Number in force	Central Mortality Rate	Number in force	Central Mortality Rate	Number in force	Central Mortality Rate
<=29	6,991	1.08	6,013	0.86	978	2.12
30-39	6,462	2.05	5,438	1.74	1,024	3.68
40-59	5,815	13.26	4,942	11.55	873	22.94
>=60	3,051	75.70	2,570	71.53	481	97.70
<b>Total</b>	<b>22,319</b>		<b>18,963</b>		<b>3,356</b>	

- [i] Calculate the directly standardised mortality rate and standardised mortality ratio separately in respect of 5-year and 10-year policies. In each case, use “all policies” population as the standard population. (5)
- [ii] Of the two summary mortality measures mentioned in (i) above, which one would you recommend should be monitored regularly? Give reasons for your recommendation. (2) [7]
- Q.6)** [i] With respect to a pension fund, outline how the benefits may be classified for the purpose of valuation of liabilities. (5)
- [ii] Explain how time selection may occur under a pension scheme. (2) [7]
- Q.7)** [i] Explain why a life insurance company will need to set up reserves. (4)
- [ii] State the conditions necessary for net premium retrospective and prospective reserve to be equal. (2)
- [iii] Demonstrate the equality of net premium reserve for a yearly regular premium paying without profit whole-life policy with sum-assured of Rs 1, stating the necessary conditions for equality. (5) [11]
- Q.8)** Employees in Company ABC can be in:
- State 0: Non-executive employee  
 State 1: Executive employee  
 State 2: Terminated from employment

Varun joins Company ABC as a non-executive employee at age 30 years exact.

You are given:

- (i)  $\mu^{01} = 0.01$  for all years of service
- (ii)  $\mu^{02} = 0.06$  for all years of service
- (iii)  $\mu^{12} = 0.02$  for all years of service
- (iv) Executive employees never return to the non-executive employee state
- (v) Employees terminated from employment never get rehired
- (vi) The probability that Varun lives up to age 65 years exact is 0.9, regardless of

Calculate the probability that Varun will be an executive employee of Company ABC at age 65 years exact. [5]

- Q.9)** A life insurance company sells a level premium 10-year increasing cover term-assurance policy for initial sum-assured of Rs. 1,00,000 to a life aged 50 years exact. The death benefit increases by Rs. 10,000 every year and the total sum-assured for the appropriate year is payable immediately on death. The premium is payable annually in advance.

Basis:

<b>Mortality</b>	<b>AM92 Select</b>
<b>Interest</b>	<b>6% per annum</b>
<b>Expenses</b>	<b>Initial: Rs 200 plus 10% of the first premium incurred at the beginning of the year</b>
	<b>Renewal: Rs 250 incurred at the beginning of each policy year from 2nd year onwards</b>
<b>Claims</b>	<b>Death: Rs 2 per 1000 sum-assured</b>

- [i] Defining  $K_x$  as curtate future life time for a life presently aged 'x', write down an expression for the gross future loss at the point of sale. (4)
- [ii] Calculate the level annual premium (7) [11]

- Q.10)** A life insurance company issues a 20-year with profits endowment assurance policy for sum-assured of Rs 50,000 to a life aged 45 years exact. The sum assured plus declared reversionary bonuses are payable at the end of the policy year of death. Level premiums are payable annually in advance.  
A simple bonus, expressed as a percentage of the sum assured, vests at the start of each year.

**Basis:**

<b>Mortality</b>	AM92
<b>Rate of Interest</b>	4% per annum
<b>Initial expenses</b>	20% of the first annual premium incurred in the beginning of the year
<b>Renewal expenses</b>	5% of all premiums excluding the first and Rs $50 \cdot (1.04)^k$ on each policy anniversary where $k$ is the exact duration of the policy on the anniversary
<b>Claim expense</b>	Rs 5 per thousand at termination of the contract

Using the principle of equivalence, calculate the level simple bonus rate that can be supported each year on this policy if the annual premium is Rs 1972.

[9]

**Q.11)** A life insurance company is working on a new regular premium unit-linked product. The product structure is as below:

- [a] Policy Term = 3 years
- [b] Annual Premium = Rs. 50,000 payable in advance
- [c] On death, the Fund Value is payable at the end of policy year
- [d] At maturity, the Fund Value is payable subject to a minimum guarantee of return of all premiums paid
- [e] The investment strategy, and hence the unit growth, will be to exactly replicate the XYZ index. The XYZ index is expected to be at the following levels at the end of each policy year.

End of Policy Year	XYZ Index level	
	Scenario (1)	Scenario (2)
0 (Current level)	15000	15000
1	16000	15500
2	15500	15250
3	16500	15750

XYZ index is expected to follow Scenario (1) with probability 0.60 and Scenario (2) with probability 0.40.

The charge structure is as below:

- [a] An Allocation Charge of 5% in Policy Year 1, 3% in Policy Year 2 and 2% in Policy Year 3, levied at the time of premium payment which is annually in advance.
- [b] A Fund Management Charge (FMC) of 1% per annum levied at the end of each Policy Year

You are required to determine the Cost of Guarantee of return of premiums at maturity. Cost of Guarantee (CoG) is the present value of the difference between the guaranteed amount and the projected fund value at maturity, subject to this difference being zero as minimum.

- [i] By projecting the unit fund for both Scenarios (1) and (2), determine the Cost of Guarantee at start of Policy Year 1. Use discount rate of 6% per annum. (8)
- [ii] Suggest two ways by which the company can reduce the Cost of Guarantee. (2)

After running many more such scenarios on the above charging structure, the company has finally decided that the Cost of Guarantee will be 2.5% of the Annual Premium and the same to be treated as an expense in each policy year. The company wants to determine the non-unit reserves. The additional assumptions to be used for calculating the non-unit reserves are as below:

- [a] Mortality Rate: 0.0010 in all years
  - [b] Unit Growth Rate: 8% per annum
  - [c] Expense: Rs.500 in all years
  - [d] Commission: 2% of Annual Premium in all years
  - [e] Rate of Interest on non-unit fund: 6% per annum
  - [f] Allocation Charge and FMC remain the same, as mentioned above
  - [g] Ignore surrenders
- [iii] Determine the non-unit reserve per policy at the end of each policy year, which should be held in order to zeroise all the negative cash flows except any negative cash flow in Policy Year 1. (6)

One of your actuarial colleagues suggests using 3% per annum as the interest rate on non-unit fund instead of using 6% per annum.

- [iv] Discuss the above suggestion. No calculations are required. (3)
- [v] Without doing any calculations, explain the impact on the profitability of reducing FMC from 1% per annum to 0.5% per annum. (2) [21]

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