Actuarial Society of India

EXAMINATIONS

18th May 2006

Subject CT5 – General Insurance, Health and Life Contingencies

Time allowed: Three Hours (10.30 – 13.30 pm)

Total Marks: 100

INSTRUCTIONS TO THE CANDIDATES

Q1) A multiple decrement table involves 3 decrements a, b, and c. In the single decrement table, the decrements a and b occur uniformly over (x, x+1) but decrement c occurs only at age $x + \frac{1}{4}$. Derive an expression for $(aq)_x^a$ in terms of q_x^a, q_x^b and q_x^c.   **[6]**

Q2) A man pays a lump sum P in order to receive an annual payment of Rs.5,000 payable continuously for 20 years or until earlier death. Thiele's equation for this benefit is :

$$\frac{_tV}{t} = (\ddot{a}+\grave{i}_{x+t}) \, _tV - 5000$$

(i) Construct this equation using a general reasoning approach   (3)

(ii) Derive this result algebraically, showing all the steps in your argument   (7)

[10]

Q3) The mortality of a population is governed by the life table function $l_x = 100 - x$, $0 \leq x \leq 100$. Calculate the values of the following expressions:

(i) $_{15}p_{45}$ (1)
(ii) $\grave{i}_{40}$ (2)
(iii) $P(T_{42}<25)$ (2)
(iv) $P(K_{53}=10)$ (2)
(v) $\ddot{e}_{33}$ (2)

[9]

Q4) Calculate the non-unit provisions required to zeroise the negative cashflows for the in-force expected cashflows (-10, -20, 5, -15, 40) for a 5-year policy taken out by a 50-year old assuming AM92 Ultimate mortality and Interest at 6% p.a.   **[6]**

Q5) Calculate values for $\ddot{a}_{45}^{(4)}$, $a_{55}^{(12)}$ and $\ddot{a}^{(2)}_{50:20}$ using AM 92 mortality and 4% pa interest.   **[3]**

Q6) An impaired life aged 35 experiences 5 times the force of mortality of a life of the same age subject to standard mortality. A two year term assurance policy is sold to this impaired life. The policy has a sum assured of Rs 2,50,000 payable at the end of the year of death. Calculate the expected present value of the benefits payable to each life assuming that standard mortality is AM92 Ultimate and interest is 4% pa.   **[6]**

Q7)

(a) Explain the difference between direct standardization and indirect standardization and give two disadvantages of direct standardization.   (3)

(b) A life insurance company sells term assurance policies with terms of either 10 or 20 years. The following table shows the statistical summary of a mortality investigation carried out for these policies. In all cases the central rates of mortality (CMR) are expressed as rates per 1,000 lives.

	All policies		10 year policies		20 year policies	
Age band	No. in force	CMR	No. in force	CMR	No. in force	CMR
- 24	6,991	1.08	6,013	0.86	978	2.12
25 – 44	6,462	2.05	5,438	1.74	1,024	3.68
45 – 64	5,815	13.26	4,942	11.55	756	22.94
65 -	3,454	75.70	2,754	71.53	481	97.70
Total	**22,722**		**19,147**		**3,239**	

Calculate the direct standardized mortality rate and the standardized mortality ratio in respect of the 10-year and 20-year policies. In each case, use the "all policies" population as the standard population.

(3)

[6]

Q8)   Members of a pension scheme are subject to 2 modes of decrements namely death (d) and withdrawal (w). The following assumptions are made in respect of the two decrements:

Independent rate q_x^d is AM92 Ultimate.

Independent rate q_x^w is 0.05 p.a. at age 20 last birthday and increases by 5% each successive age attained (e.g. the annual rate of withdrawal at age $20 + t$ last birthday is $(0.05) \times (1.05)^t$);

The decrements are statistically independent.

Each decrement is uniformly distributed in its single decrement table.

Calculate the probability that a new entrant aged exactly 20 will withdraw from the scheme at age 22 last birthday.

[5]

Q9   A life insurance company issues a 4-year unit-linked endowment contract to a male aged 45 years exact under which level premiums of Rs.5,000 p.a. are payable in advance. In the first year 50% of the premium is allocated to units and 102.5% in the second and subsequent years. The units are subject to a bid-offer spread of 5% and an annual management charge of 0.5% of the bid value of the units is deducted at the end of each year.

If the policyholder dies during the term of the policy, the death benefit of Rs.50,000 or the bid value of the units after the deduction of the management charge, whichever is higher, is payable at the end of the year of death. On surrender or on survival to the end of the term, the bid value of the units is payable at the end of the year of exit.

The company has the following assumptions in its profit test of this contract:

Rate of growth on assets in the unit fund: 6% p.a.

Rate of interest on non-unit fund cashflows: 4% p.a.
Independent rates of mortality: AM92 Select

Independent rates of withdrawal: 10% p.a. in the first policy year
                                      5% p.a. thereafter

Initial expenses: Rs.650 plus 100% of the amount of initial commission
Renewal expenses: Rs.250 p.a. on the second and subsequent years

Initial commission: 10% of first premium
Renewal commission: 2.5% of second and subsequent years' premiums

Risk Discount Rate: 8% p.a.

Calculate the profit margin on the assumption that the office does not zeroise future
negative cashflows and that decrements are uniformly distributed over the year.   **[13]**

Q10) Describe the relative advantages and disadvantages of the three systems of bonus
allocation?   **[3]**

Q11) On 1 April 2001 an insurer issued a block of 20 year annual premium endowment
policies that pay Rs.1,00,000 at maturity or Rs. 50,000 at the end of the year of
earlier death to lives aged exactly 40. The premium basis assumed is 4% interest,
AM92 Select mortality and allowed for an initial expense of Rs. 650 and renewal
expenses of 2% of each subsequent premium. Reserves are calculated on the same
basis as the premiums.

  (i) Calculate the premium   (3)
 (ii) Calculate the reserve required per policy at 31 March 2006 independently using a
prospective and a retrospective formula.   (6)
(iii) There were 205 policies in force on 1 April 2005. During the period 1 April 2005 to
31 March 2006, there were 15 deaths, interest was earned at twice the rate expected
and expenses were incurred at twice the rate expected. By considering the total
reserve required at the start and end of the year, and all the cashflows during the
year, calculate the profit or loss made by the insurer from all sources (not just from
mortality) in respect of these policies for the Financial Year 2005-2006.   (6)
                                                                                    [15]

Q12) A life insurance company uses the following model for pricing and valuing sickness
and other contracts:
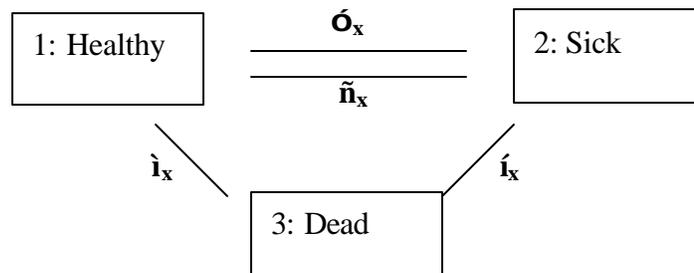
$p_{x,t}{}^{ab}$ is the probability that a life now aged x and is in state *a* will be in state *b* when
aged x+t.

$p_{x,t}{}^{\overline{aa}}$ is the probability that a life now aged x and in state *a* will remain continuously in state a until x+t.

Explain what is represented by each of the following integrals:

(i)   65-x
   $$\int_0^{65-x} 12{,}000\, e^{-\ddot{a}t}\, p_{x,t}{}^{12}\, dt$$
0   (2)

(ii)   30   30-t
   $$\int_0^{30}\int_0^{30-t} 10{,}000\, e^{-\ddot{a}t}\, p_{35,t}{}^{\overline{11}}\, \acute{o}_{x+t}\, p_{35+t}{}^{\overline{22}}\, dr\, dt$$
0   0   (2)

[4]

Q13)   A pension fund has the following features:
  (i)   The pension is based on 1/80th of the average of salary over the final 3 years' service for each year of service.
 (ii)   Members contribute 5% of salary each month.
(iii)   The death and withdrawal benefit is a refund of members' contributions with interest at 2%.
        Using the pension fund actuarial tables, find the contribution by the employer paid as a percentage of salary annually at the beginning of the year, if 4% interest is assumed, for a new entrant at age 30 whose salary is Rs.2,000.

        State any assumptions made.   **[10]**

Q14)   A man aged 40 purchases a whole life assurance policy with a sum assured of Rs.50,000 payable at the end of the year of death. Premiums of Rs.650 are payable annually in advance. Calculate the variance of the insurer's profit on this contract, assuming AM92 ultimate mortality and 6% interest. Ignore expenses.   **[4]**

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