

**M.Sc. ACTUARIAL SCIENCE
(MSCAS)**

Term-End Examination

December, 2012

**MIA-009 (F2F) : GENERAL INSURANCE, LIFE AND
HEALTH CONTINGENCIES**

Time : 3 hours

Maximum Marks : 100

*Note : In addition to this paper you should have available
Actuarial table and your own electronic calculator.*

SECTION-A

(Answer *any five* questions.)

1. Evaluate the following functions, assuming the given basis :

(a)	$\ddot{a}_{65 : \overline{20} }$, AM92 Ultimate mortality and interest rate at 4% p.a.	2
(b)	$A_{68 : \overline{2} }$, AM92 Ultimate mortality and interest rate at 6% p.a.	2
(c)	$\ddot{a}_{50 : \overline{15} }^{(12)}$, AM92 Ultimate mortality and 4% p.a. interest.	2
(d)	\ddot{a}_{65160} based on PA92C20 mortality and 4% p.a. interest, if (65) represent a male life and (60) represent a female life.	2

2. Define, stating any assumption that you make, the present value random variable of an endowment assurance contract where the death benefit is payable at the end of the year of death and derive its mean and variance. 8

3. (a) Calculate the value of $0.5^4 62.25$ using assumptions of : 4

(i) a uniform distribution of death

(ii) a constant force of mortality

Basis : PMA92C20

(b) If $l_{40} = 1000$ and $l_{40+t} = l_{40} - 5t$ for $t = 1, 2, \dots, 10$, calculate the value of $A_{40 : \overline{10}|}$ at 6% p.a. interest. 4

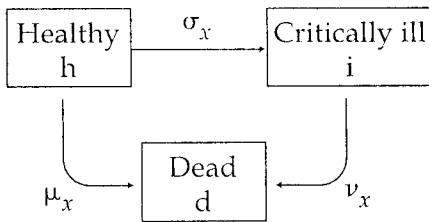
4. A man pays a lump sum P in order to receive an annual payment of Rs. 10,000 payable continuously for 25 years or until earlier death. Thiele's equation for this benefit is : 8

$$\frac{\partial t\bar{V}}{\partial t} = (\delta + \mu_{x+t})t\bar{V} - 10000$$

Derive this result algebraically, showing all the steps in your argument.

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5. The rules of a pension scheme require members to contribute 5% of earnings each month for a maximum of 40 years. Assuming that the interest rate, salary scales and decrements are the same as in the table, calculate.
- (a) The expected present value of future contributions for a member now aged exactly 25 with 3 years of past service whose earnings during the last 12 months were Rs. 15,000. 5
- (b) The expected present value of an ill-health retirement benefit of Rs. 1000 p.a. payable continuously to the member in (a) above. 3
6. A life insurance company sells a term assurance and critical illness policy with a 20 year term to a life aged 40 exact. The policy provides a benefit of Rs. 50,000 payable immediately on death or earlier diagnosis of critical illness. No further benefit is paid in the event of death within the term after a prior critical illness claim has been paid. The company prices the policy using the following multiple state model. 8



Calculate the expected present value of the benefits under the policy.

Basis : $i = 5\%$ per annum

$$\mu_x = 0.005 \text{ at all ages}$$

$$\nu_x = 0.006 \text{ at all ages}$$

$$\sigma_x = 0.003 \text{ at all ages}$$

7. A certain population is subject to three modes of decrement : α , β and γ .

- (a) Write down an expression for $(aq)_x^\alpha$ in terms of the single decrement table probabilities q_x^α , q_x^β and q_x^γ , assuming each of the three modes of decrement over the year of age x to $x+1$ in the corresponding single decrement table. 2
- (b) Suppose now that in the single decrement table α , ${}_tP_x^\alpha = 1 - t^2 q_x^\alpha$ ($0 \leq t \leq 1$), while decrement β and γ remain uniformly distributed. Derive a revised expression for $(aq)_x^\alpha$ in terms of the single decrement table probabilities q_x^α , q_x^β and q_x^γ . 6

SECTION-B

(Answer *any four* questions.)

8. A life insurance company issues the following policies :

- 15-year term assurance with a sum assured of Rs. 15,000 where the death benefit is payable at the end of the year of death.
- 15 year pure endowment assurance with a sum assured of Rs. 75,000
- 5 year single premium temporary immediate annuities with an annual benefit payable in arrear of Rs. 25,000.

On 1 January 2002, the company sold 5000 term assurance policies and 2000 pure endowment policies to male lives aged 45 exact and 1000 temporary immediate annuity policies to male lives aged 55 exact. For the term assurance and pure endowment policies, premiums are payable annually in advance. During the first two years, there were fifteen actual deaths from the term assurance policies written and five actual deaths from each of the other two types of policy written.

- (a) Calculate the death strain at risk for each type of policy during 2004. 9
- (b) During 2004, there were eight actual deaths from the term assurance policies written and one actual death from each of the other two 6

types of policy written. Calculate the total mortality profit or loss to the office in the year 2004.

Basis :

Interest : 4% per annum

Mortality : AM92 Ultimate mortality for term assurances and pure endowments, PMA92C20 for annuities.

9. Two lives, a female aged 60 exact and a male aged 65 exact, purchase a policy with the following benefits : 15

- an annuity deferred ten years, with Rs. 20,000 payable annually in advance for as long as either of them is alive.
- a lump sum of Rs. 1,00,000 payable at the end of the policy year of the first death, should this occur during the deferred period.

Level premiums are payable monthly in advance throughout the deferred period or until earlier payment of the death benefit.

Calculate the monthly premium.

Basis :

Mortality : Female PFA92C20

Male PMA92C20

Interest : 4% per annum

Expenses : Initial Rs. 350

Renewal 2.5% of each monthly premium excluding the first.

10. On 1 May 1998, a life insurance company issued a whole life with-profits policy to a life then aged exactly 45. The basic sum assured was Rs. 50,000. The sum assured and attaching bonuses are payable 3 months after the death of the policyholder. Level monthly premiums are payable in advance for the whole of life. The company calculated the premium on the following basis :

Mortality : AM92 select

Interest : 6% pa

Bonus loading : 1.9231% p.a. compound, vesting at the end of each policy year.

Expenses : Initial : Rs. 300

Renewal : 5% of each premium, excluding the first.

Termination : Rs. 200 payable at the same time as the death benefit.

- (a) Show that the monthly premium is Rs. 85.65. The company hold gross premium retrospective reserves for the policy, calculate on the following basis : 7

Mortality : AM92 select

Interest : 4% p.a.

Past bonuses : 4% p.a. compound,
vesting at the end of each
policy year.

Expenses :

Initial : Rs. 300

Renewal : Rs. 5 at the start of each
month, excluding the first.

Termination : Rs. 100 payable at the
same time as the death
benefit.

(b) Calculate the reserve for the policy on 8
30 April 2005.

11. A life insurance company issues a number of 3-year term assurance contracts to lives aged exactly 60. The sum assured under each contract is Rs. 2,00,000, payable at the end of the year of death. Premiums are payable annually in advance for the term of the policy, ceasing on earlier death.

The company carries out profit test for these contracts using the following assumptions :

Initial expenses : Rs. 200 plus 35% of the
first year's premium.

Renewal expenses : Rs. 25 plus 3% of the
annual premium, incurred
at the beginning of the
second and subsequent
years.

Mortality : AM92 Ultimate

Investment return : 7% per annum

Risk discount rate : 15% per annum

Reserve : One year office premium

- (a) Show that the office premium, to the nearest pound, is Rs. 2527, if the net present value of the profit is 25% of the office premium. 10
- (b) Calculate the cash flows if the company held zero reserves throughout the contract, using the premium calculated in part (a) 2
- (c) Explain why the company not hold reserves for this contract and the impact on profit if they did not hold any reserves. 3
12. (a) An n -year term assurance with a sum assured of 1 payable at the end of the year of death is issued to a life aged x . Level premiums are payable annually in advance throughout the term of the policy or until the policyholder's earlier death. The premium includes an initial expense loading of I , and a renewal expense loading of e at the start of each policy year, including the first.

Give expression, in terms of standard actuarial functions for :

- (i) the gross premium 1
 - (ii) the prospective gross premium reserve at integer time $t < n$. 1
 - (iii) the retrospective gross premium reserve at integer time $t < n$. 1
- (b) Hence show that, if all three of the expressions in (a) are calculated on the same basis, the prospective and retrospective gross premium reserves are equal. 5
- (c) Derive a formula for the variance of the profit earned by an insurance company offering an n -year endowment assurance policy to lives aged x . Assume that premiums are payable annually in advance and death benefits are payable at the end of the year of death. 7
13. (a) Explain what is meant by the following terms and give an example of each : 12
- (i) temporary initial selection
 - (ii) time selection
 - (iii) spurious selection

- (b) In a country the select period for published mortality tables for assured lives often extends up to 15 years. Discuss whether or not you consider that a select period of this length can be justified. 3
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